PROCEEDINGS 2023

ISSN 1857-7636

INTERNATIONAL SCIENTIFIC CONFERENCE
GEOBALCANICA 2023
8-9 MAY 2023
SKOPJE, NORTH MACEDONIA

GEOBALCANICA

9TH INTERNATONAL SCIENTIFIC CONFERNCE
G E O B A L C A N I C A 2 0 2 3

PROCEEDINGS

08-09 May, 2023
Skopje, North Macedonia

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Published by: Geobalcancia Society – Skopje, North Macedonia

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IMPACT OF CLIMATE CHANGES AND OPERATION OF DAM RESERVOIRS ON TEMPORAL AND SPATIAL VARIABILITY OF ICE COVER OCCURRENCE ON CARPATHIAN RIVERS

DOI: https://doi.org/10.18509/GBP23003f
UDC: 551.583:[556.535.04:627.8.034(234.58:438)

Maksymilian Fukś
Department of Geoenvironmental Research, Institute of Geography and Spatial Organization, Polish Academy of Sciences, Poland

ABSTRACT

This article describes the influence of dam reservoir operations and climate change on the temporal and spatial variability of ice cover occurrence on Carpathian rivers during the period 1900–2020. Ice cover occurrence data were obtained for 10 water gauge cross-sections located on eight rivers in the Polish part of the Carpathians: Wisła, Soła, Skawa, Raba, Dunajec, Jasiołka, Wisłok, and San. Air temperature data for the studied period were obtained from the University of East Anglia's resources. The acquired data were subjected to statistical and spatial analysis. The analysis showed that the currently observed climate changes in the study area have resulted in decreased river ice cover frequency. Additionally, within the total ice cover, a decrease in the proportion of static ice cover and an increase in the proportion of border ice is observed. The pressures of climate change are compounded by the impact of dam reservoir operations; these dams intensify the changes occurring in downstream river sections and also distort the relationship between air temperature and ice cover occurrence. As a result of the interplay between these factors, the sections of rivers below the reservoirs experience significant ice cover formation disturbance. This disturbance manifests itself as a significant decrease in the number of days annually with ice cover, especially in the period 1991–2020. In some river sections after reservoir installation, static ice cover stopped forming.

Keywords: river ice, climate change, dam reservoir, Carpathian Mountains

INTRODUCTION

Ice cover is one of the periodic ice phenomena that occur on large areas of rivers in temperate and circumpolar climate zones. Ice cover, especially its most developed form (total river ice), represents the culmination of the ice cycle and is the most stable ice phenomenon that occurs on rivers [1]. In its simplest division, ice cover can be divided into total ice cover and shoreline icing: however, it is often difficult to clearly distinguish between these forms in practice [2].

The main factor determining river ice cover occurrence is water temperature. In Poland, ice cover formation usually begins at the end of November or the beginning of December due to radiation of heat from the water's surface to the atmosphere, which cools it to a temperature close to 0°C [3]. Throughout this process, the air temperature plays the most important role and is crucial to heat flux exchange between the water surface and the atmosphere. Due to the relationship between ice cover formation, water temperature, and air temperature, the currently observed global climate change plays an important role in the temporal and spatial distribution of ice cover. Recent studies have shown that over much of the globe, there is a reduction in the duration of ice cover on rivers, later ice formation, and earlier ice breakup [4], [5], [6], [7]. There is also a downward trend in the average thickness of river ice cover [8], [9]. Studies based on satellite observations and modeling methods have shown that the average ice cover duration on the world's major rivers is decreasing by around 6.1 days for every 1°C increase in average global temperature [6]. The impact of climate change on the temporal and spatial distribution of river ice cover is now relatively well understood; however, the vast majority of studies to date have focused on large lowland rivers. The literature currently lacks studies that analyze the relationship between climate variability and the occurrence of ice cover on small mountain rivers. While climatic factors play a key role in controlling ice processes on large rivers, it is also important to investigate small rivers, where other factors such as the presence of hydrotechnical developments, thermal pollution, channel morphology, flow volume and velocity, and groundwater recharge methods may also play important roles [10].

Dam reservoirs represent an element of the geographic environment that affects ice cover formation processes on rivers. The occurrence of thermal stratification within the reservoir causes the warming of water flowing out of the reservoir relative to water entering it during the winter. This process disrupts the river’s thermal continuum [11] which can translate directly into changes in ice cover formation processes. Studies conducted to date in this context have shown that constructing reservoirs results in significantly reduced ice cover occurrence below the reservoir [12],[13],[14].

Although the Polish Carpathian Mountains occupy only 6% of the country's area, they are of great hydrological importance. These mountains form the source area of the Vistula River and some of its right-bank tributaries. The area's water supply is the highest in Poland, ranging from 8 $l/s/km^2$ in the foothill valleys to 50 $l/s/km^2$ in the Tatra Mountains [15]. Despite the area’s hydrological importance, there is a lack of current research on the temporal and spatial distribution of ice cover on the rivers of the Polish Carpathians. The last comprehensive studies on this topic were conducted in the late 1950s and early 1960s [16], [17].

Given this lack of research, the main objective of the present study is to present the temporal and spatial variability of ice cover occurrence on Polish Carpathian rivers from 1900 to 2020, in the context of ongoing climate change and the construction and operation of dam reservoirs.

RESEARCH AREA

All of the river sections selected for the study are located in the Outer Western Carpathians, within the borders of Poland (Fig. 2). The rivers in the area are characterized by the early spring runoff regime of Haines et al. [18]. Consequently, these rivers experience large fluctuations in flow volume on an annual basis. The Carpathian rivers are characterized by gradients exceeding 100‰, which translate into high flow velocities and often turbulent water flow behavior [19]. A characteristic element of the area’s river network is the presence of dam reservoirs, whose operation transforms the hydrodynamics of the rivers on which they are situated [20]. The climate of the study area is highly diverse, mainly due to the steep gradients of the area’s terrain and its varied morphology [21].

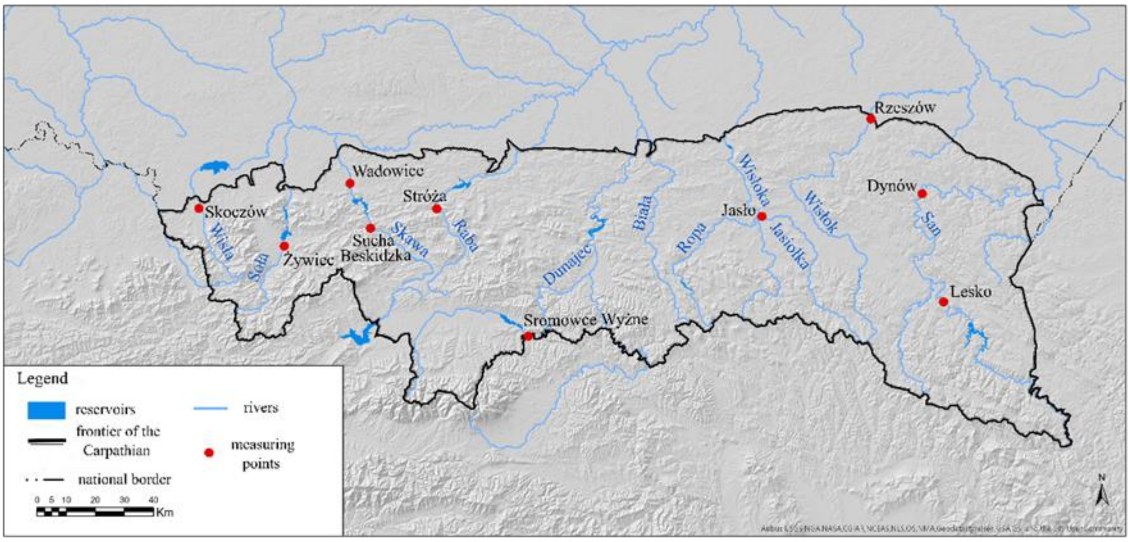

Figure 1. Location of the analyzed water gauge cross-sections within the Polish Carpathians

The Outer Western Carpathians are located within five climatic floors in Hess' division — from moderately cold to moderately warm [22]. The lowest average annual air temperatures are recorded in the peaks of Beskid Zywiecki (-2 to 0°C) while the highest values are recorded in the foothills (6–8°C). The average annual precipitation ranges from 800 mm to 1400 mm.

METHODS

To investigate the temporal and spatial variability of ice cover occurrence in the Polish Carpathians, measurement series from 10 water gauge cross-sections located on eight rivers, covering the years 1900–2020, were developed. The main criterion for selecting the water gauge cross-sections was observational data availability. Data for ice cover occurrence during the period 1900–1960 were compiled based on the works "Zlodzenie rzeki polskich" and "Zjawisko lodowe na rzekach polskich" [16], [17]. Data for 1960–1980 were obtained from the Hydrological Yearbooks of the National Hydrological and Meteorological Service. For the period 1980–2020, data were obtained from the online resources of Poland's Institute of Meteorology and Water Management – National Research Institute. To obtain the greatest possible continuity of observations at each water gauge cross-section, data gaps were filled using data from neighboring stations. Data describing the average air temperature for individual months from 1900 to 2020 were obtained from the resources of the Climate Research Unit at the University of East Anglia. These data were derived from the Climatic Research Unit gridded Time Series (CRUTS) database, which was created based on measurements from climatological stations that were then interpolated onto a grid with a resolution of 0.5° longitude and latitude [23]. These data were selected because they have previously been successfully applied in studies of ice phenomena [24],[25] and are available for the entire period 1900–2020. Data showing the locations of dam reservoirs were obtained from the orthophotos available on Geoportal 2. To show the spatial distribution of the occurrence of ice phenomena on rivers, maps were constructed showing the average number of days per year with ice cover for 30 years and the percentage of days with total ice cover and coastal ice as a fraction of the total number of days with ice cover for 30 years. To analyze the time series, the course of annual totals of days with ice cover, the nonparametric Mann–Kendall test was used. This test involves detecting a trend by analyzing the signs of the difference between successive values. The statistic (S) used in the test is calculated from the relationship:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i)$$

where:

$$gn(x) = \begin{cases} +1\ dla\ x > 0 \\ 0\ dla\ x = 0 \\ -1\ dla\ x < 0 \end{cases}$$

and {x1, x2, …, xn} is a set of data in the form of a time series.

To calculate the relationship between the data sequence and the corresponding time step, the rank correlation coefficient of Kendall's tau is calculated according to the formula:

$$\tau = \frac{S}{n(n-1)/2}$$

where τ takes values from -1 to 1. Low values of this coefficient indicate the presence of a decreasing trend, high values indicate an increasing trend, and values close to zero indicate the absence of a trend. A change at the 95% confidence level ($\alpha < 0.05$) was considered statistically significant. To determine the relationship between air temperature and the occurrence of ice cover on the Carpathian rivers, scatterplots illustrating the relationship between the average January temperature and the number of days with ice cover in this month were constructed for each station, and Pearson's linear correlation coefficients were calculated. January was selected as the month for analysis for two reasons. First, it was necessary to exclude periods in which ice cover formation and breakup occur: including the other winter months in the analysis would have resulted in the inclusion of long periods when the air temperature is above 0 °C but ice phenomena do not occur, which would have significantly affected the results. Secondly, limiting the correlation analysis to January allowed the results to be interpreted in the context of dam reservoir influence, given that thermal stratification within the reservoirs is highly likely during this period.
Based on the compiled data, an attempt was made to determine the influence of climate change and the presence of dam reservoirs on the temporal and spatial variability of ice cover occurrence on Carpathian rivers. This involved a comparison between the results obtained from cross-sections influenced by reservoirs and cross-sections in which there is no reservoir influence.

RESULTS

The spatial distribution of ice cover on the Carpathian rivers is characterized by an increasing trend in the number of days when this phenomenon occurs from west to east. In the 30-year periods 1901–1930, 1931–1960, and 1961–1990, the lowest average number of days per year with ice cover was characterized by cross-sections in the western and central parts of the study area, located on the Vistula, Soła, Skawa, and Raba rivers, with values from 20 to 46 days. River sections in the eastern and southern parts of the Polish Carpathians (Dunajec, Jasiołka, Wisłok, and San) were ice-covered much more frequently during the studied period. In these areas, the average number of days with ice cover ranged from 30 to 67 days (Fig. 2).

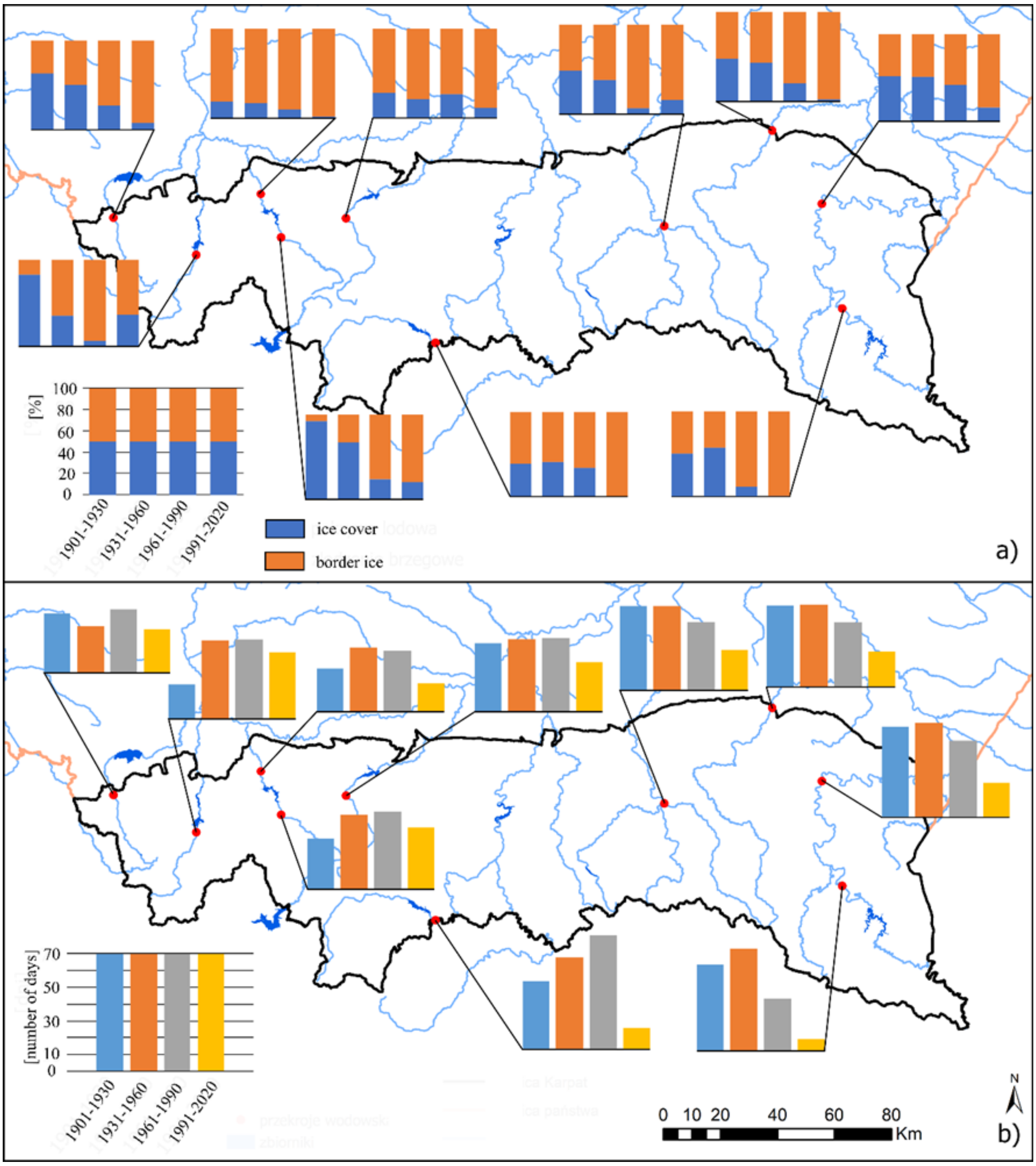

Figure 2. Spatial distribution of ice cover occurrence: a) percentage of each ice cover type (riverbank ice and total ice cover) from 30-year periods and b) average number of days per year with ice cover from 30-year periods

However, the situation differed slightly in the 30-year period 1991–2020. During this period, the lowest average number of days per year with ice cover was characterized by rivers with cross-sections located below large dam reservoirs, e.g., cross-sections in Lesko (7 days), Sromowce Wyżne (12 days), and Wadowice (16 days), whereas the highest values were located in the northern and western parts of the study area, e.g., Sucha Beskidzka (37 days) and Żywiec (39 days). Most of the analyzed cross-sections clearly indicate more frequent shoreline cover occurrence relative to total ice (Fig. 3).

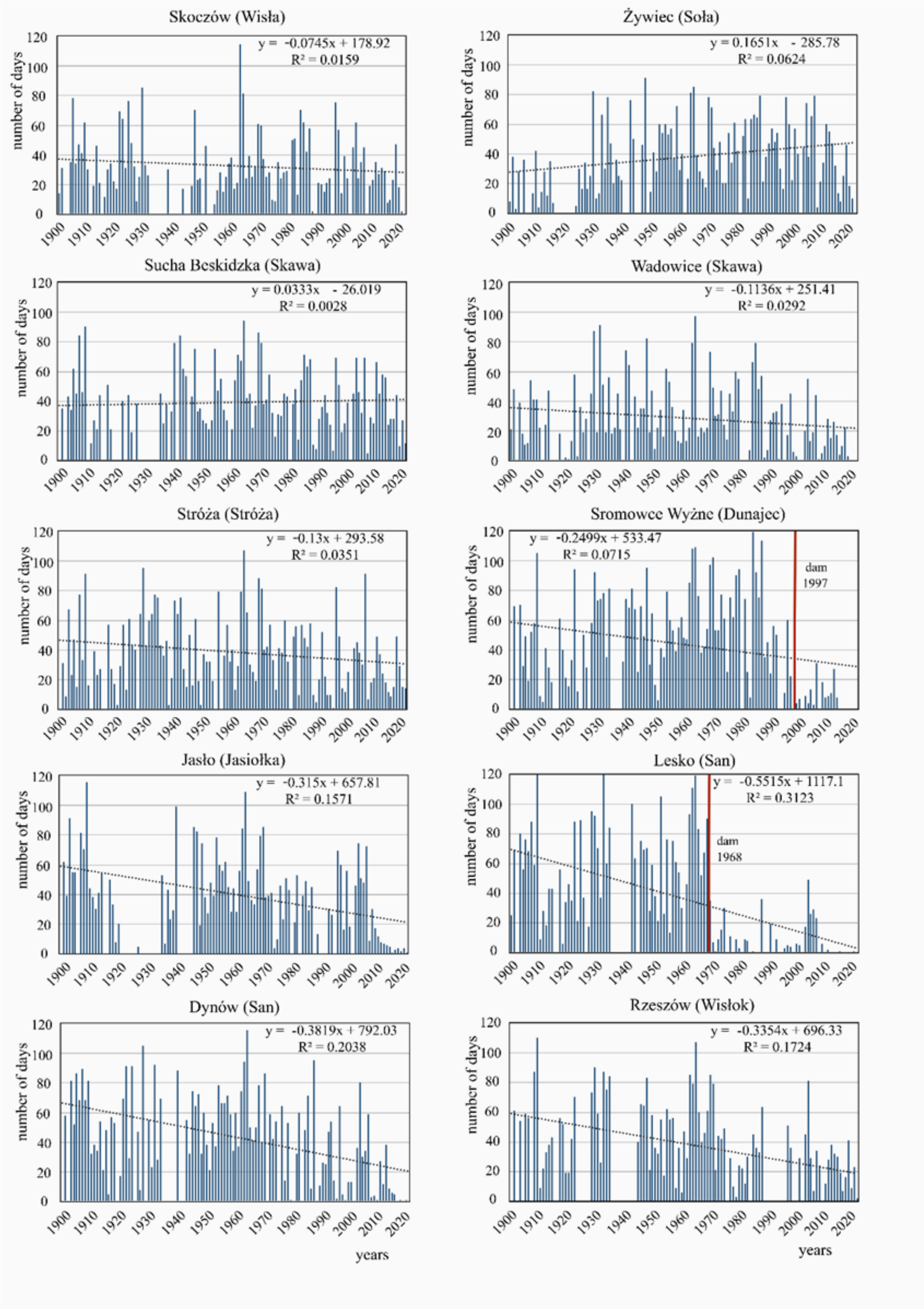

Figure 3. Sum of days with ice cover for the analyzed water gauge cross-sections

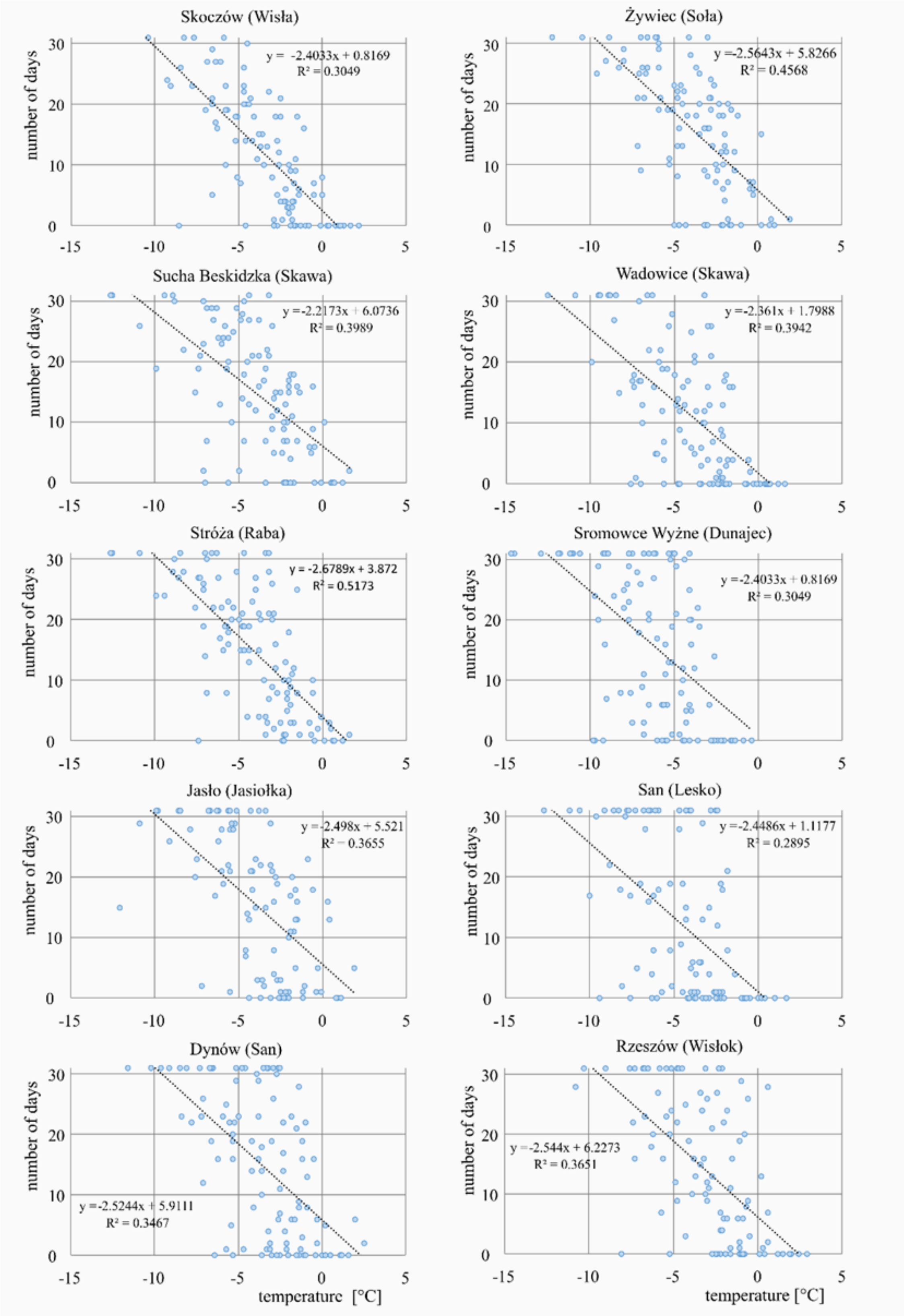

Figure 4. Mean air temperature in January and number of days with ice cover for gauge cross-sections

In the period 1901–1930, the percentage of border ice in the total of days with ice cover was the smallest of all the periods analyzed, ranging from 8.1% to 83.3%. During this period at some stations (mainly in the western part of the study area), total ice cover was more frequent. In later periods, a gradual decrease in the proportion of total ice cover is recorded, with an increase in the incidence of border ice.
The total ice cover was the least frequent relative to shoreline ice during the period 1991–2020. In this period, the share of total ice cover as a fraction of the total number of days with ice cover averaged 11% in the analyzed cross-sections. Its lowest shares were recorded at cross-sections in Lesko (0.5%), Rzeszów (2.1%), and Wadowice (1.9%). At the cross-section located in Sromowe Wyżne, total ice cover was absent during this period. At eight of the 10 water gauge cross-sections, statistically significant trends were detected in terms of the annual sums of days with ice cover. The Mann–Kendall test results, presented in Table 1, indicate decreasing trends at seven cross-sections (Rzeszów, Dynów, Lesko, Jasło, Sromowce, Stróża, and Wadowice) and an increasing trend at one cross-section (Żywiec). The trends were not statistically significant at the cross-sections in Skoczów and Sucha Beskidzka.

Table 1. Mann–Kendall test results

Parameter	Skoczów (Wisła)	Żywiec (Soła)	Sucha Beskidzka (Skawa)	Wadowice (Skawa)	Stróża (Raba)	Sromowce Wyżne (Dunajec)	Jasło (Jasiołka)	Lesko (San)	Dynów (San)	Rzeszów (Wisłok)
Kendall Tau	-0.092	0.166	0.012	-0.130	-0.134	-0.205	-0.298	-0.447	-0.321	-0.301
Statistics Test (S)	-463	919	67	-825	-825	-1263	-1408	-2475	-1842	-1527
p-value	0.175	0.012	0.855	0.043	0.038	0.001	<0.0001	<0.0001	<0.0001	<0.0001
Significance level (α)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

The largest downward trends in the mean annual sum of days with ice cover were represented by water gauges located in Lesko, Dynów, and Rzeszów (Fig. 4), as evidenced by their relatively high Kendall's tau values (> -0.3). In all analyzed cross-sections, common sub-periods can be identified in which ice cover occurred less frequently or more often relative to the average occurrence. The periods 1900–1910 and 1960–1970 were characterized by high numbers of annual days with ice cover, whereas periods with relatively few annual days with ice cover are 1910–1920, 1990–2000, and 2007–2020 (Fig. 4).
Strong and very strong negative correlations [26] were recorded between the average January air temperature and the number of days with ice cover, as measured by Pearson's linear correlation coefficient, in all the studied cross-sections. The strongest correlation between these environmental elements occurred at the Skoczów (-0.74) and Stróża (-0.72) water gauge crossings. In Rzeszów, Jasło, Wadowice, Sucha Beskidzka, and Żywiec, the correlation coefficient ranged between -0.60 and -0.68. The weakest correlation values were found at the Lesko (-0.54), Czorsztyn (-0.55), and Dynów (-0.59) stations. In addition, the ice cover formation process on the analyzed river sections was also influenced by other factors, as evidenced by the scatter diagrams shown in Fig. 5. In all the analyzed cross-sections, some months had the same average air temperature but marked differences in the number of days with ice cover. This was particularly evident at

cross-sections located below dam reservoirs. For example, at the cross-section in Sromowce Wyżne, there were months in which the average air temperature was above -5 °C and ice cover occurred throughout the month in addition to months in which the average air temperature was below -9°C and ice cover was not observed. A similar pattern was observed at the cross-section located in Lesko: in some months the average air temperature was around -2.5°C and ice cover persisted for the entire month, while in others the average air temperature was below -6°C and the ice cover did not form. These patterns were also observed in cross-sections located outside of the range of reservoir influence, but they occur there much less frequently

DISCUSSION CONCLUSIONS

The main factor determining the temporal and spatial distribution of ice cover occurrence at all surveyed cross-sections is air temperature. This is evidenced by the strong negative Pearson's linear correlation coefficient values recorded between air temperature and the number of days with ice cover at all water gauge cross-sections. The primary importance of this factor is also evidenced by the observed decline in the number of days with ice cover in the 1990s and in the 21st century as well as the decline in the proportion of total ice cover relative to shoreline ice at most of the studied water gauge cross-sections. This trend is commonly recorded on most rivers with ice cover both in Polish and global literature [27], [8], [5], [28]. The positive trend of increasing days with ice cover identified in the Żywiec cross-section is due to the occurrence of a relatively small number of days with ice cover in the period 1900–1915, with no statistically significant trend recorded for the period 1915–2020.

The second factor that significantly affected the number of days with ice cover in some of the analyzed cross-sections was the presence of dam reservoirs. The influence of these reservoirs was visible in the study area at the cross-sections located in Sromowce Wyżne, below the Czorsztyn–Sromowce reservoir complex, and in Lesko, below the Solina–Myczkowce reservoir complex. In these cross-sections, a marked decrease in ice cover frequency was recorded in the period after the reservoir was put into operation relative to the period before its operation. At the water gauge cross-section in Lesko, the average number of annual days with ice cover in the 20-year period 1948–1968 (before the reservoir's construction) was 62 days; in contrast, in the 20-year period 1969–1989 (after the reservoir's construction), the equivalent value was 9.1 days. A similar scenario was observed at the cross-section in Sromowce Wyżne. In the 20-year period before the opening of the Czorsztyn reservoir (1976–1996), the average number of days with ice cover per year was 55.4 days, while the equivalent annual value in the subsequent 20-year period (1997–2017) was 8.7 days. These results are consistent with the findings of previous studies on the impacts of dam reservoirs on the thermal regime of Carpathian rivers. Wiejaczka et al. [29] showed that the Czorsztyn–Sromowce reservoir system in winter warms the waters flowing out of it relative to the inflowing ones by 0.2°C to 2.6°C, and this effect can reach distances of up to several tens of kilometers downstream. The thermals and characteristics of ice phenomena were also studied for the Rożnów–Czchów reservoir complex [30]. These studies showed that river sections below these reservoirs are characterized by a lower intensity of ice phenomena and more winters without ice cover were recorded in these areas. In addition, the appearance of ice cover in the section not influenced by the reservoir was found to require different meteorological conditions. The influence of dam reservoirs on river ice cover formation has also been noted on other rivers within the Carpathians. The construction of the Klimkówka dam reservoir was

found to have reduced the annual duration of ice cover on the Ropa River by up to a dozen days [31]. The influence of dam reservoirs on the relationship between air temperature and ice sheet formation is evidenced by the fact that at cross-sections below the reservoirs (Lesko and Sromowce Wyżne), the weakest Pearson's linear correlation values between these parameters were recorded. These cross-sections are also marked by relatively frequent winter months without ice cover despite low average monthly air temperatures.
Based on the results, it can be concluded that dynamic changes in river ice cover occurrence are taking place in the Polish Carpathians. In the studied period, the number of days with ice cover decreased at most of the analyzed water gauge cross-sections. In addition, a decrease in the share of total ice cover and an increase in the share of coastal ice as a fraction of total ice cover was observed. These changes are driven by climate change, as evidenced by the fact that they are observed in most of the analyzed cross-sections. The pressure from climate change is further compounded by the impact of the operation of dam reservoirs. These reservoirs intensify the changes taking place in downstream river sections and also disturb the relationship between air temperature and ice cover occurrence. Given this finding, it would be valuable to conduct research on the extent and magnitude of the impact of dam reservoirs on river ice cover based on more data of various types, including remote sensing data.

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TREND ANALYSIS AND TIME SERIES DECOMPOSTION ON HYDROLOGICAL PROFILE MOJSINJE IN THE JUZNA MORAVA RIVER BASIN

DOI: https://doi.org/10.18509/GBP23015d
UDC: 519.246.8:556.535.047(282.2:497.11)

Dobrić Milica
Durlević Uroš
Čegar Nina
Faculty of Geography, University of Belgrade, Belgrade, **Serbia**

ABSTRACT

The Juzna Morava basin covers an area of 15,469 km^2, its surface area and hydrological peculiarities require constant research. Imbalances of small, medium and large waters, torrential and erosive events are frequent. Average flows are statistically obtained values, which are most often used in practice when analyzing and preparing studies for further monitoring purposes The non-parametric Mann-Kendall test and Sen's slope estimation were applied for trend observation, and the Pettit test was used to determine the breaking point in the analyzed time series. Data collected on the hydrological profile of Mojsinje (Juzna Morava) in the time interval 1961-2020 were processed The average annual flow (Qavg) is the most important hydrological indicator for observing trends in longer time series; mean monthly and seasonal flows were also analyzed. Based on the applied tests, it was determined that the water level on the hydrological profile decreases (-0.70m^3/s/year) without statistical significance, while the results obtained for May are the most significant (-2.10m^3/s). The breaking point of the average discharges for most of the data series was recorded in the early 1980s (1982–1984), which coincides with the pluviometric regime in the basin. The analysis of seasonal hydrological events in the basin shows negative trends, most significant in winter. In order to determine wet and dry years, they have been classified according to water richness using the SDI index.

Keywords: flow, Moisinje, Juzna Morava, Man Kendall test, Pettit's test

INTRODUCTION

The United Nations classifies water resources as critical natural resources on which the development of society, the economy, and the ecosystem depend substantially [43]. In a global sense, it can be said that water is inexhaustible, but if we consider the amount of water suitable for human use, water pollution, certain areas threatened by water shortages or sanitary water, then water resources should be considered limited.

The flow regime is capable of integrating several components of a river basin. This hydrological variable has a variation in time and can be directly influenced by the climate (mainly by precipitation), basin physical characteristics and anthropic alterations, such as the changes in the use and occupation of the soil and damming of fluvial waters [7],[15],[31],[34]. Anthropic activities combined with climate change have contributed to changes in the hydrological cycle [14]. Increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security, with the largest impacts observed in many locations and/or communities in Africa, Asia, Central and South America, Small Islands and the Arctic. Roughly half of the world's population currently experience severe water scarcity for at least some part of the year due to climatic and non-climatic driver [18]. According to the IPCC AR6 Synthesis Report (2022) continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation, and very wet and very dry weather and climate events and seasons

Average annual flow (Qavg) is the basic indicator for studying the water regime of river courses and the main indicator for observing trends in longer time series. In recent decades, about 31 percent of 145 main rivers in the world have shown significant statistical changes in their annual flow [43],[8]. Statistical methods such as linear regression tests, direct correlation analysis, and non-parametric analysis including Mann–Kendall, modified Mann–Kendall, Sen's slope, and innovative trend analysis (ITA) are widely used to detect trend and change point in historical series of climatic and hydrological variables [24],[36],[16],[40],[19].

Observing changes in longer hydrological time series is important for scientific and practical research [22]. Numerous authors have studied the river flow in Iran [33], Canada [40], China [1], Portugal [6], South Africa [28]. Statistical analysis of mean annual and seasonal flows was the subject of numerous hydrological studies in Serbia: on the example of the Nišava River [25], [9], [10], Sava river [39] Zapadna Morava [21], Južna Morava [3],[23],[30],[32].

In this paper, the mean annual, monthly and seasonal discharges in the Južna Morava River were analyzed. The data obtained on the hydrological profile of Moisinje in Južna Morava for the period (1961-2020) were analyzed using the Mann Kendall and Pettit's test. The aim of the work is to determine whether there is a statistically significant trend in the change of flows, as well as aburpt change. The Južna Morava was chosen for the study area because its valley has enormous national, geostrategic and socioeconomic importance. Although the river and its tributaries are not navigable, it represents the main backbone for the life and work of people in the valley.

STUDY AREA

The course of the Juzna Morava was formed in a tectonic trench, which was created in the middle of the Tertiary, more precisely in the oligo-miocene. During the existence of the Pannonian Sea, in the Pontian stage, the valley of today's Juzna Morava represented a bay that stretched to the south to the Grdelica Gorge [29]. According to Gavrilović Lj. and Dukić D. [4], Juzna Morava is formed by the joining of Binačka Morava and Preševska Moravica near Bujanovac, belongs to the Black Sea basin, and the average flow at the mouth is 100 m^3/s. The length of its course is 295 km, and if its source arm, i.e. Binačka Morava, is taken into account, the total length of the course is 343 km. The area of the South Morava basin is 15,469 km^2, of which 85% belongs to Serbia, while smaller parts belong to Bulgaria and North Macedonia. Near Stalać, it merges with Zapadna Morava, forming Velika Morava.

Figure 1. Juzna Morava basin

Juzna Morava has a complex valley which, according to Marković [29], consists of a series of gorges and structural basins with an average height above sea level of 657m. South Morava has 157 tributaries, the most important of which are: Vlasina, Veternica, Jablanica, Pusta reka, Toplica, Vranjska reka, Sokobanjska Moravica and Nišava (the longest).

Climatological features of the researched area are characterized by a moderate continental climate with an average annual amount of precipitation in the basin of 550 mm and in the river valley 1300 mm per year. The average annual air temperature is in the range of 10–12ºC in the lowest parts of the basin, while in the mountainous parts (above 1500 m) temperatures are below 3ºC [2]. Most of the rivers in the South Morava basin belong to the pluvio-nival type of water regime, with maximum flows in March and April, and minimum flows in August and September. Based on previous research on natural hazards in the territory of Serbia, the South Morava valley from Vladičini Han to Stalac has been classified as a potential flood zone [23].

There are 6 hydrological profiles in South Morava and they are (going from the source to the mouth): Vranjski Priboj, Vladičin Han, Grdelica, Korvingrad, Aleksinac and the most upstream, which was also analyzed in the work of Mojsinja.

DATA AND METHODS

During the research, the data werw taken from Republic Hydrometerological Institute (RHMZS), [42], measured on the hydrological profile of Mojsinje in the time interval 1961-2020. The average annual flow (Qavg) is the main hydrological indicator by which trends are observed in longer time series, and in addition to it, the following were analyzed: average maximum and minimum annual and monthly flows, the resulting analysis of flows by season is presented.

At the beginning of the research, the ranking years by water level was carried out using the SDI index (Streamflow Drought Index). The water content of a given year actually shows how much excess or lack of water occurs in relation to the normal, or usual, water content, represented by the mean value of annual flows. The Streamflow Drought Index (SDI) is often used to rank small water bodies [26]. Calculating the index is simple. For each year, the mean flow for the studied period is subtracted from the flow value and the result is divided by the standard deviation of all flows. In this way, positive values are obtained indicating that the flow is above the average and negative values if the flow is below the average [10].

The Mann-Kendall test [24], [11] was used for trend analysis. The test belongs to the group of non-parametric statistical trends that treats series that are not normally distributed, and its use is based on multi-year data series. Mann–Kendall is commonly used to detect monotonic trends in climatological and hydrological research. The Z statistic was used to test significance. A positive value of Z indicates an upward trend, while a negative value of Z indicates a negative trend [17]. The null hypothesis of the Mann-Kendall test is based on the assumption that there is no monotonic trend in the time series. Control statistics are used to test the null hypothesis [11]. If the Z value (significance level) is greater than 1.96 (corresponding to the significance threshold of 0.05), we conclude that there is a monotonic trend in the time series, otherwise, if the value is lower, the trend does not exist [39]. Sen's estimate of the slope (Sens's estimate) shows us the estimate of the slope of the linear trend and shows us the average value of changes in a unit of time [34]. Therefore, it is necessary to use several full cycles of the time series, in order to create a representative trend [39]. In order to detect significant changes in the time series of hydrological data, the Petit test (Pettit's test) was used. The Petit test also belongs to the group of non-parametric tests and is most often used to detect sudden changes (points of change) in hydrological data. The Pettit test is a method that detects a significant change in the mean of a time series when the exact time of the change is unknown. X 1, x 2, x 3, …x n is a sequence of observed data that has a change point ut such that x 1, x 2 …, x t has a distribution function F 1 (x) that differs from the distribution function F 2 (x) of the second part of the sequence x t+1, x t+2, x t+3 ..., x n. When the value of the test statistic is less than the chosen confidence interval, the null hypothesis is rejected and there is no distinct change point in the time series (Jaiswal et al., 2015).

RESULTS AND DISCUSSION

Some river streams are extremely rich in water, while other streams barely had enough water to cover the stream bed in certain years, for this reason, in hydrological and geographical studies, the method of classification from year to year according to water wealth is of great importance, which indicates a multi-year trend the flow of the river.

Based on the mean annual flow value, for the observed series of data (1961-2020) and with calculated standard deviations, years were classified according to water wealth.

For each year, the mean flow value for the studied period is subtracted from the flow value and the result is divided by the standard deviation of all flows. In this way, positive values are obtained indicating that the flow is above average and negative values if the flow is below average. The higher the index values, the waterier the year and vice versa. Eight categories of years were distinguished by water content [10].

Table 1. Classification of water years on the hydrological profile of Moisinje (1961-2020)

SDI index categories	Year
Extremly watery >2	1963, 2010
Very watery 1.5-2	1980,2015
Moderately watery 1.0-1.5	1962, 1965, 1970, 1973, 1976,2005, 2018
Medium watery 0.0-1.0	1965, 1969, 1974, 1975, 1977,1978, 1981,1984, 1987, 1996, 1997, 1999, 2003, 2006, 2009, 2016,
Medium dry -1.0-0.0	1961,1964, 1966, 1971,1972,1979,1982,1983,1985,1986,1988,1989,1990, 1991,1992,1993,1995,1998,2000,2002,2004,2007,2008, 2012,2017,2020,
Moderately dry 1.5-1.0	1968,2000,2001,2010,2013,2019,
Very dry 2.0-1.5	1994
Extremly dry <2	1993

The index applied to the data series (1961-2020) gave the following results. In the 60-year period, there are the fewest extreme (1) and very dry (1) years, then extreme (2) and very wet (2), moderately dry (6), moderately wet (7), and the highest frequency of slightly wet (17) and slightly dry (23) years.

By using the Log-Pearson III distribution as a statistical basis for ranking years according to water content, categories are obtained whose boundaries are expressed in flow values. This is a problem if we want to compare rivers that have different flow values, which is often the case. Therefore, it is necessary to introduce indices that would eliminate the absolute magnitudes of flows. The water content of a given year actually shows how much excess or lack of water occurs in relation to the normal, or usual, water content, represented by the mean value of annual flows. One of the indixes is the Streamflow Drought Index (SDI), which is often used to rank small water bodies [26].

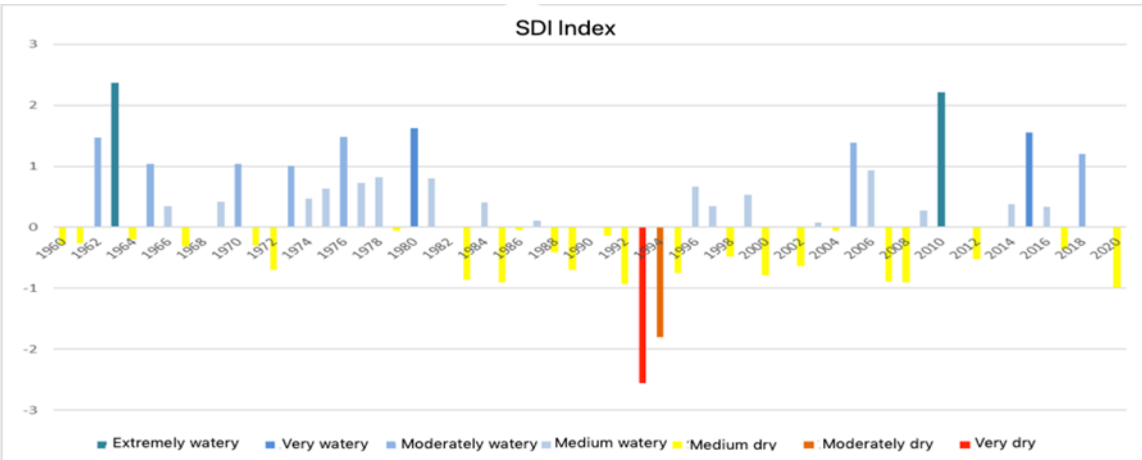

Figure 2. Graphic representation of the distribution of years by water content and hydrological profile of Moisinje (1961-2020)

Flow is the most important element of the water regime and is closely related to the water level. Average flows are statistically obtained values, which are most often used in practice when analyzing and creating studies for the needs of further monitoring.

Table 2. Average annual and average monthly flow, average annual and average monthly maximum and minimum flow on the hydrological profile of Moisinja (1961–2020) [42].

	Jan	Feb	March	Apr	May	June	July	Avg	Sep	Okt	Nov	Dec	Year
Average flow Q avg (m^3/s)	93.4	141.3	178.8	175.3	131.3	86.0	47.0	30.0	26.7	35.1	52.0	78.3	**89.6**
Average minimum flow Qmin (m^3/s)	50.3	67.6	94.7	97.1	70.4	44.8	26.9	18.9	**17.2**	21.4	26.7	40.3	**21.8**
Average maximum flow Qmax (m^3/s)	202.8	311.8	366.6	**384.0**	272.1	198.9	103.8	54.9	56.3	73.2	127.6	185.9	**244.5**

The flow is a variable hydrological element, it changes under the influence of primarily the physical and geographical factors of the watershed. There is no doubt that the climate of the watershed is the most important factor in these changes, primarily precipitation and its regime, on which the flow itself depends the most. Juzna Morava valley lacks precipitation. A continental rainfall regime is represented here, with a maximum in May and June. In June, 12% to 13% of the total annual precipitation falls. The least amount of precipitation occurs in February and October, when it falls from 5% to 6% of the total annual amount of precipitation. Due to the higher altitude, Vlasina and Krajište receive a higher amount of precipitation than the valley of Juzna Morava. The mountains of the region receive larger amounts of rain and snow, over 1000 mm [29].

The average mean annual flow of the Juzna Morava near Mojsinje for the observation period 1961 - 2020. is 89.6 m^3/s. The maximum mean monthly flows are recorded in March and April, and the minimum in August and September. Large spring waters with a maximum in March and April are conditioned by the melting of snow in the higher parts of the basin and the pluviometric regime. After that, there is a decrease in average flows and low water occurs in summer and early autumn with a minimum in August and September, due to less rainfall and high evaporation, then the flow increases constantly until April.

The movement of the average minimum and maximum flow follows the movement of the annual average, so the absolute minimum flow occurs in August (18.9 m^3/s) and September (17.2 m^3/s), while the absolute maximum in March (366.6 m^3/s) and April amounts to (384.0 m^3/s).

Table 3. Mann-Kendall test results for mean annual and mean monthly flow measured on the hydrological profile in Moisinje (1961-2020)

	Trend(Z)	Sen's estimate (B)	Level of significance (α)
January	-1.00	-0.329	/
February	-1.31	-0.678	/
March	-0.53	-0.360	/
April	-0.42	-0.277	/
May	**-2.10**	**-0.876**	*
June	-1.41	-0.382	/
July	-0.77	-0.115	/
August	0.94	-0.093	/
September	-0.89	-0.058	/
October	0.63	-0.052	/
November	-0.04	-0.008	/
December	-0.28	-0.105	/
Per year	**-1.97**	**-0.424**	*

*** - significance level 0,001; **- significance level 0,01; *- significance level 0,05; +- significance level 0,1

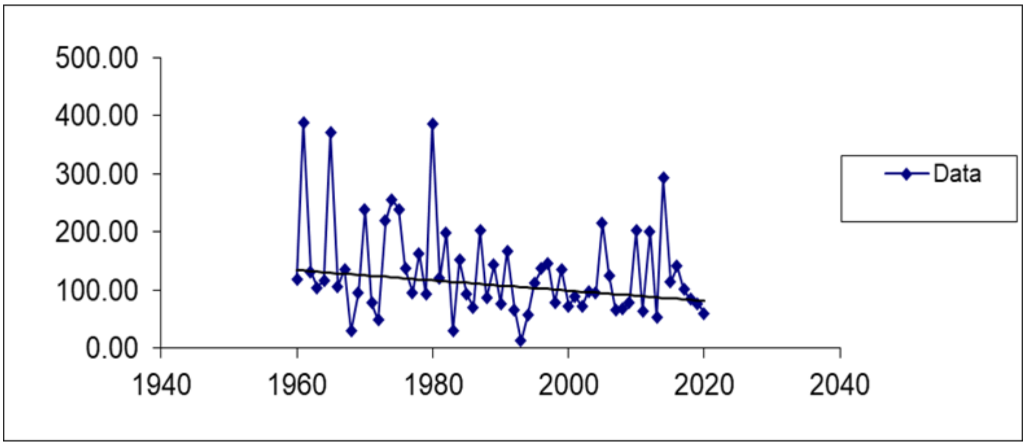

Figure 3. Trend of mean annual flow on the hydrological profile of Moisinje (1961-2020)

The trend method provides more concrete values and a clearer insight into the changes that occur over a longer period of years. According to Table 2 and Figure 2, we see that the trend obtained by applying the Mann-Kendel test showed that the level of significance is minimal, i.e. marked with 0.05 for the entire analyzed period, and that the value of Z is negative, and that the total loss according to the trend line by Sen's method (-0.424 m^3/s) which means that it is decreasing in trend units for the observed period.

The trend applied to the average monthly flow data showed that the value is significant only in the month of May and that Z= -2.10, and the level of significance marked with *(0.05), the trend is decreasing along the trend line (-0.876 m^3/s). So we applied the Petit test on those values.

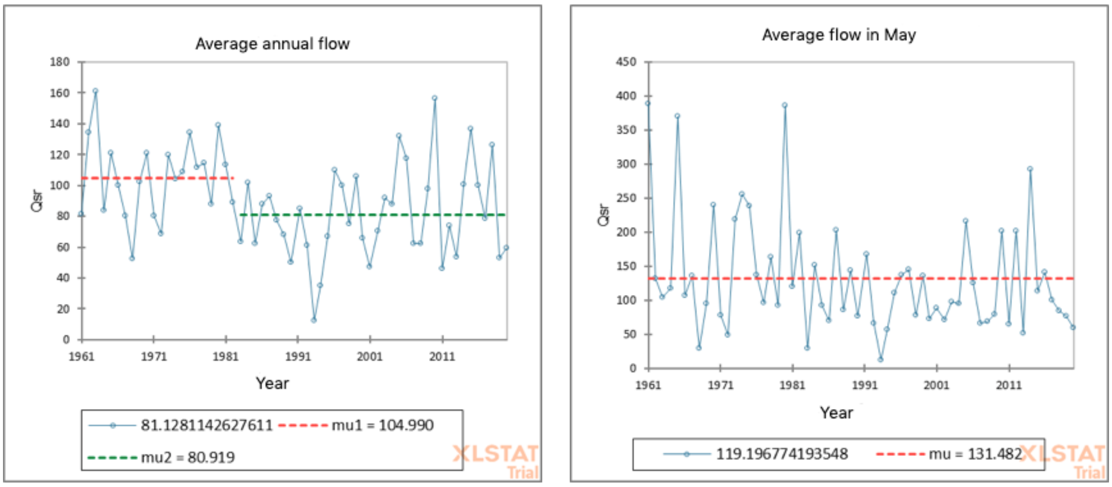

Figure 4. Graphic representation of the results of the Pettit's test for the mean annual flow and the average conflict in the month of May measured at the Moisinje hydrological profile (1961-2020)

According to Petit's test, significant changes were determined in the series of data, when the point of change was not clearly defined. According to the test, the statistically significant breaking year for the time series of 60 years is 1982 and the value is p=0.020. Which tells us that the flow that year at the hydrological station decreased from 104.99 m^3/s to 81.12 m^3/s, that is, there is a change in the negative direction. The fact that the significance level is less than 0.05, the alternative hypothesis is accepted and it can also be concluded that the observed time series are not homogeneous. The most statistically significant trend was recorded in the month of May, so the Petit test was also applied to the average monthly flows obtained for the month of May where we come to the result that 1982 was marked as a point of change, which is without major statistical significance. We classified the average flows according to the seasonal hydrological profile of Moisinje analyzed for the period 1961-2020. Average monthly flows are grouped into four climatological periods with the aim of seeing the regularity and trend of flow movements. It is important to emphasize that in the analysis of the winter period, we analyzed December from the previous calendar year. For the analysis of seasonal flows, the most important influencing factors are climatic factors, i.e. temperature, amount of precipitation and the pluviometric regime that follows the seasons.

Table 4. Mann-Kendall test results for mean seasonal flow on the Moisinja hydrological profile (1961-2020)

Climatological seasons	Trend(Z)	Sen's slope estimate (B)	Level of significance (α)
Winter period (December, January, February)	-1.12	-0.391	/
Spring period (March, April, May)	-1.-88	0.61569	/
Summer period (June July August)	-0.90	-0.146	/
Autumn period (September, October, November)	0.56	0.066	/

*** - significance level 0,001; **- significance level 0,01; *- significance level 0,05; +- significance level 0,1

The trend obtained by applying the Mann-Kendell test on the values of the series of data of mean monthly flows grouped by seasons do not show greater statistical significance. We have data on the establishment of a negative trend that follows the winter, summer and spring periods in which it is most prominent (-0.615 m^3/s), while a positive trend appears in the autumn period (0.066 m^3/s). The increase in the autumn period on the hydrological profile of Moisinje is a logical sequence because it follows the pluviometric regime and the gradual increase of precipitation in the researched area. According to Majkic& Urosev [12], who conducted a similar study (2014), in the autumn period, a slight and gradual autumn increase in flow was observed at 86% of hydrological stations in Serbia. Since the application of the test did not lead to the establishment of a trend with a higher level of significance, the Petitt test was not applied to this series of data.

CONCLUSIONS

The study of changes in the values of hydrological parameters in long time series and the observation of trends are important data for understanding the global state of water in river basins. In this research of the mean annual flow values in the Juzna Morava basin, on the hydrological profile of Moisinja for the period 1961-2020. were used as a basic hydrological indicator. The non-parametric Mann-Kendall test with Sen's estimate of the slope (Sen's estimate) was used to analyze a series of data in order to determine whether there are statistically significant trends and to quantify changes on an annual basis.

The general conclusion is that the annual flows are the highest during the spring months, and the lowest in the summer and autumn periods. Based on the applied tests and methods, it was determined that the water content on the hydrological profile is decreasing and that the Z value is negative, and that the total loss according to the Sen's method trend line is (-0.424 m^3/s), which means that it is decreasing in the trend unit for the observed period. The trend applied to the average monthly flow data showed that the value is significant only in the month of May and that Z= -2.10, and the level of significance is marked with 0.05, and it decreases along the trend line (-0.876 m^3/s). The analysis of average monthly flows by season resulted in the establishment of a negative trend that follows the winter, summer and spring periods in which it is most prominent (-0.615 m^3/s), while a positive trend appears in the autumn period (0.066 m^3/s). The amount of precipitation has the greatest influence on changes in river flow in the Juzna Morava basin due to its intensity, shape and pluviometric regime. In addition to the influence of physical and geographical factors, the flow of the Juzna Morava is also influenced by anthropogenic activities, i.e. water management activities.

The research can serve as a starting point for subsequent hydrological research, which could be based on the study of minimum and maximum flows for the research area, and the study and definition of extremes.

The results of the study contribute to the understanding of the water quality of the Juzna Morava stream, and can be useful to emergency management services, the energy sector and the local governments within which the Juzna Morava flows.

Acknowledgements

The study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Contract number 451-03-68/2022-14/200091).

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THE GEOTOURIST MAP OF CIUCAȘ MOUNTAINS (EASTERN CARPATHIANS, ROMANIA) – MODEL REGARDING CAPITALIZATION OF GEOMORPHOSITES

DOI: https://doi.org/10.18509/GBP23027c
UDC: 528.94:551.4]:338.48(234.421.1:498)

Laura Georgiana Comănescu
Alexandru Nedelea
Tiberiu Alexandru Iurea
Geomorphology-Pedology-Geomatics Dept, Faculty of Geography, University of Bucharest, **Romania**

ABSTRACT

The Geotourist map is a synthetic cartographic product that starts from the Tourist Map (on which natural and anthropogenic tourist attractions and infrastructure are represented) to which elements of geology and geomorphology (especially geosites and geomorphosites) are added. The map is based on the documentation of the specialized literature, the use of topographic maps and aerial images as well as detailed mapping in the field. The case study chosen is Ciucaș Mountains located in Eastern Carphatians (Romania). The main objective of our paper is to introduce into the tourist activity a series of geomorphosites of great value, insufficiently known and exploited, and the creation of geotourist routes: the differential erosion route and the subalpine route.

Keywords: geotourist map, geotourist routes, geomorphosites, Ciucaș Mountains, Carpathians, Romania

INTRODUCTION

The geotourist map is a relatively new type of map, which combines information related to geology and relief (primarily geosites and geomorphosites) with those of tourist interest (natural and anthropogenic tourist attractions, access infrastructure - different categories of roads and paths, access by cable, accommodation infrastructure, food and leisure, belvedere points, etc.). Their use has become more and more important, with the increased development (especially in Europe) of geotourism. They also have an educational function, this representing a basic geotourism product through which geoeducation is carried out (the transmission of knowledge from various fields related to geosites and geomorphosites).

The first cartographic representations of this type belong to the Italian school of geomorphology [1] [3] [4] [5] [6] [7], followed by other countries in the Alpine area, such as Switzerland [2] [14]. Later, the use of the geotourist map was extended to several countries, most of them with large mountainous areas (Morocco, Spain, Poland, Czech Republic, France, Serbia, Brazil, etc.).

In Romania, the first contributions of this kind are related to the Oradea school of geomorphology for the Băile Felix resort [12], by the geomorphologists from the University of Bucharest [8] [9] [10] for the Bucegi Mountains and those of the Babeș-Bolyai University Cluj Napoca (Măcin Mountains, Trascău Mountains).

The main objective of this paper is to create and analyse the geotourist map of the Ciucaș massif, a massif that presents a varied range of geomorphosites of great value, insufficiently known and exploited. This must be achieved through geotourism. In addition, two geotourist routes have been created, which are representative and interesting for tourists, such as: the subalpine route and the differential erosion route.

STUDY CASE

The case study chosen is represented by the Ciucaș Mountains located in the southern part of the Eastern Carpathians (Romania) (Figure 1), having as neighbouring units: Clăbucetele Buzăului (N), Grohotiș Mountains (W), Teleajenului Subcarpathians (S) and the Siriu Mountains (E). They have a relatively central position in the Curvature Carpathians and show intense flows of tourists due to the concentration of a large number of valuable tourist spots (related to geology, relief, hydrography, vegetation and anthropogenic) as well as high accessibility due to the presence of national roads, forest or of tourist trails on all sides of the massif [11]. The most important access point is the Cheia resort.

The Ciucaș Mountains are made up of two subunits: Ciucaș massif (north of the springs of Teleajen, it has a central peak, with the maximum altitude in Ciucaș peak-1,954 m, with numerous ruin-shaped relief forms, with a fairly extensive subalpine floor) and the Grohotiș massif (located between the Telejean and Doftana valleys, it is composed of rounded peaks and large plateaus, with altitudes varying between 1,100-1,500 m, mainly covered with forests) [11].

They are made up of conglomerates with limestone elements which are part of the internal flysch, to which is added the presence of a broadly fold structure that led to the imposition of structural plateaus and steeps on the ends of the strata (to the West and East) [13].

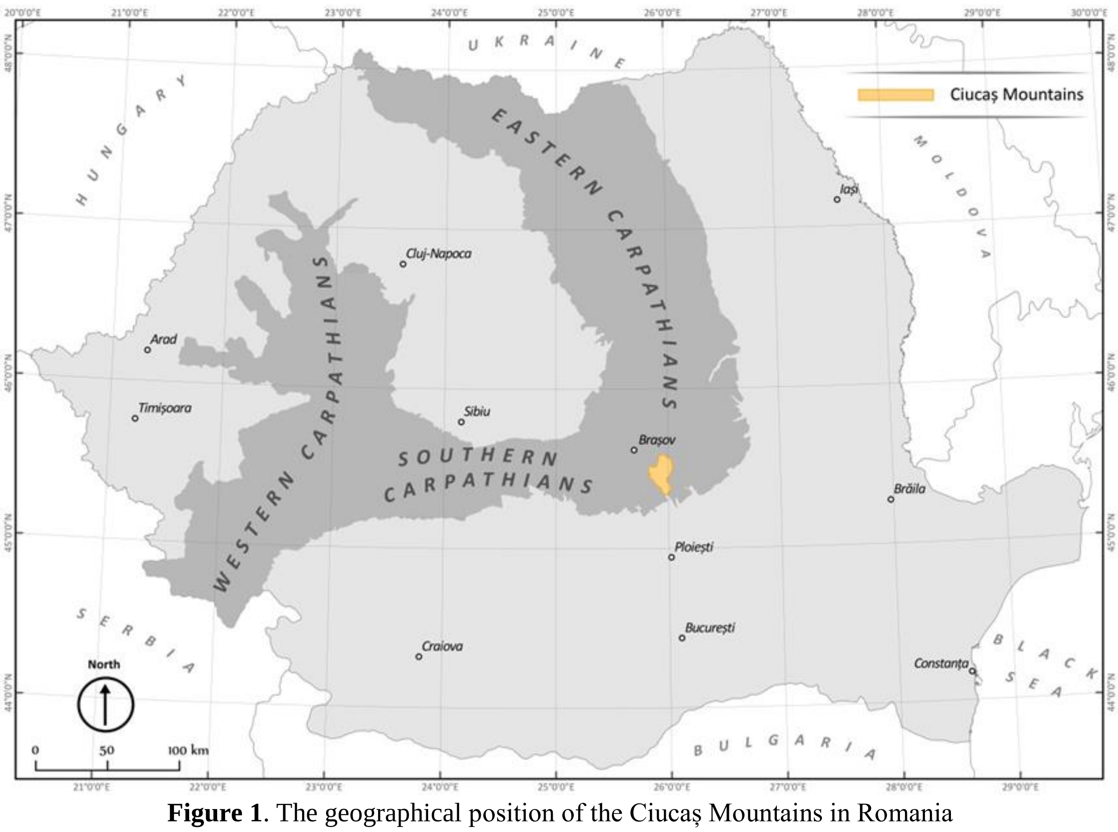

Figure 1. The geographical position of the Ciucaș Mountains in Romania

The relief is the result of the interaction in time and space of internal and external agents, resulting in different genetic types of relief such as: fluvial, periglacial, nival, denudational, structural and petrographic.
The most important and representative types of geomorphosites that can be used in tourist activity are ([11], with additions) (Figure 2):
-the cliffs, the columns, the towers around the peaks of Ciucaş, Colţii Nitrii, Tigăile, Zăganu, Grohotiş;
-the ridges in the Gropșoarele - Zăganu area;
-peaks that constitute important belvedere points such as Ciucaș -1,954m, Gropșoarele -1,883m, Zăganu -1,817m; Tigăile Mari -1,845m, Bratocea -1,827m, Zăganu -1,817m, Muntele Roșu -1,765 m, Tigăile Mici -1,717m;
-pyramidal or dome-shaped peaks on conglomerates (Dungu, Muntele Roşu, Bobu) or limestone (Tesla);
-the structural plateaus in the Chiruşca Mountain, Berii Valley or in the East of the Colţii Nitrii ridge;
-the narrow gorges with steep slopes along Teleajen, Valea Albă, Stânei Valley, Tesla, Șipote, Cheița, some of which appear waterfalls;
-landforms of differential erosion: Bratocei Sphinx, Tigăile Mari, Tigăile Mici, Babele la Sfat, Mâna Dracului (Five-fingered hand), Goliath Tower, Gemenii Ciucașului, Căprioarei Tower, Podul de Aramă, Porumbelul, Moș Crăciun, Triangular Tower, Red Tower, Muntelui Roșu Needles, Bratocei Needles, Zăganu Needles;
-cuesta fronts developed along the Bratocea-Tigăi interfluves - Nitrii peak - Zăganu mountains alignment;
-hogbacks in the Zăganu Mountains;
-steep structural slopes of over 500 m with scree and rock torrents;
-nival microdepressions, niches and cirques resulting from snow accumulations (Chirușca, Bratocea interfluves and at the origin of the Stânelor valley);
-nival valleys in the shape of the letter U, with a length of about 500 m, located at the origin of the Berii, Stânei and Chirușca valleys;

METHODOLOGY

To create the geotourist map, several steps must be followed, this being the result of combining geology/geomorphology information with tourist geography information (Figure 3). Thus, in the first stage, the documentation related to the analysed area is carried out from the specialized literature (works in geology, geomorphology, hydrology, vegetation and fauna, protected areas, geography of tourism, but also from related fields such as history, ethnography, architecture, religion) and from the cartographic database (tourist maps at different scales, topographic maps from various editions, orthophotos and aerial images).
The next stage consists in field trip, where the information from the first stage is completed and updated, the mapping of the most important landforms, the inventory of geomorphosites and their location on the cartographic support, the identification of natural and man-made tourist attractions, infrastructure elements and their representation on the cartographic support.
In the further of the approach, specialized SIG software (including information from own flights) is used to represent information related to geology, relief and those of tourist interest, as well as other elements that may be useful in carrying out tourist activities (for

example: natural protected areas, slopes where you can practice winter sports, vegetations, springs).
Usually, on the back of the map, various geographical information, spot, routes and tourist facilities, useful addresses and phone numbers, marked routes, proposed routes are presented.
This mapping product has multiple uses (for orientation in the field, for information and preparation of tourist activities or for didactic purposes). Depending on the purpose for which the map was made and used, it can be in the traditional format (on paper) or online (by accessing a specialized site, when the possibility of updating is permanent).

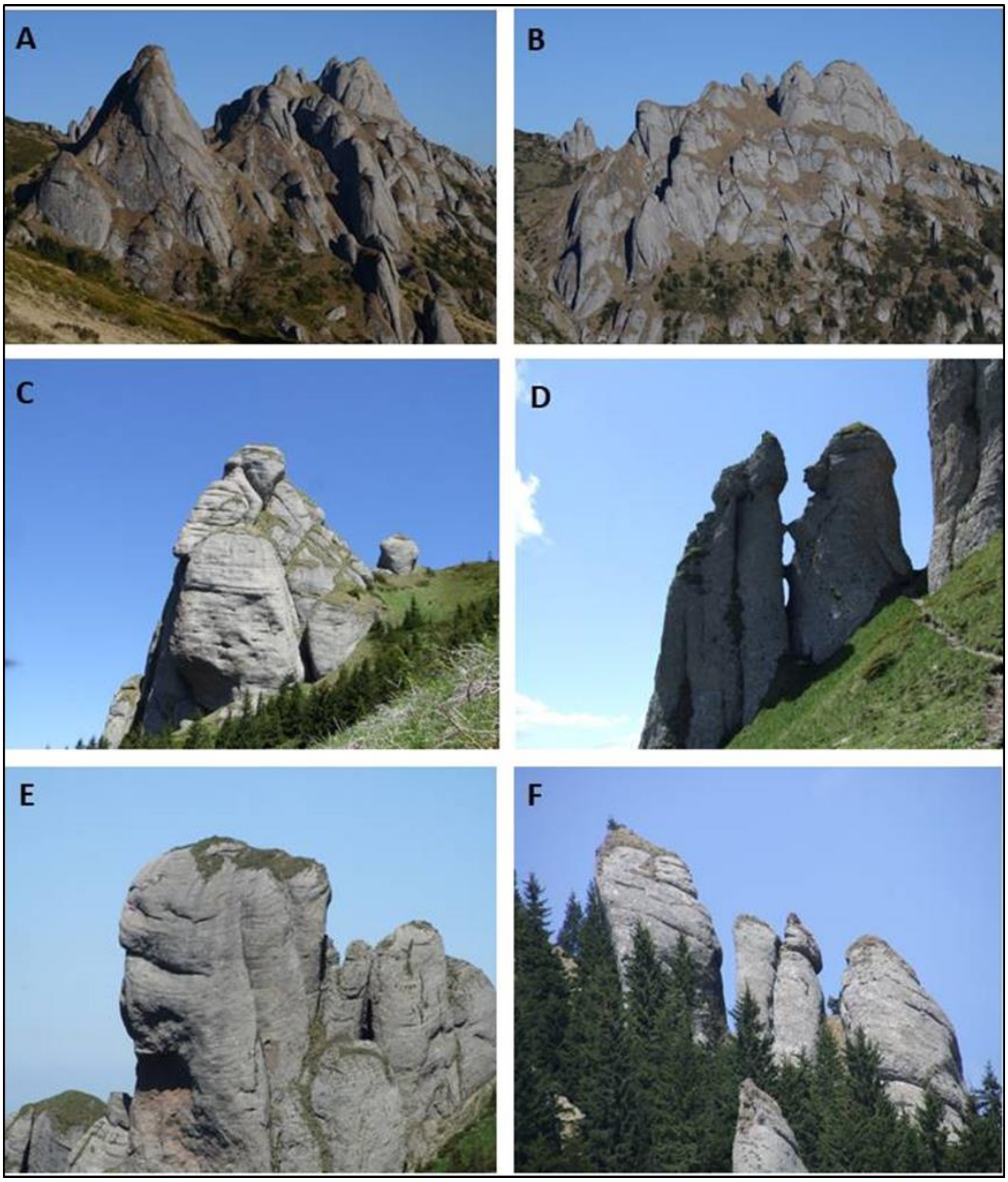

Figure 2. The most important geomorphosites in Ciucaș Mts (original) (A- Tigăile Mari, B-Tigăile Mici, C- Goliat Tower, D- Babele la Sfat, E- Bratocei Sphinx, F- Bratocei Needles)

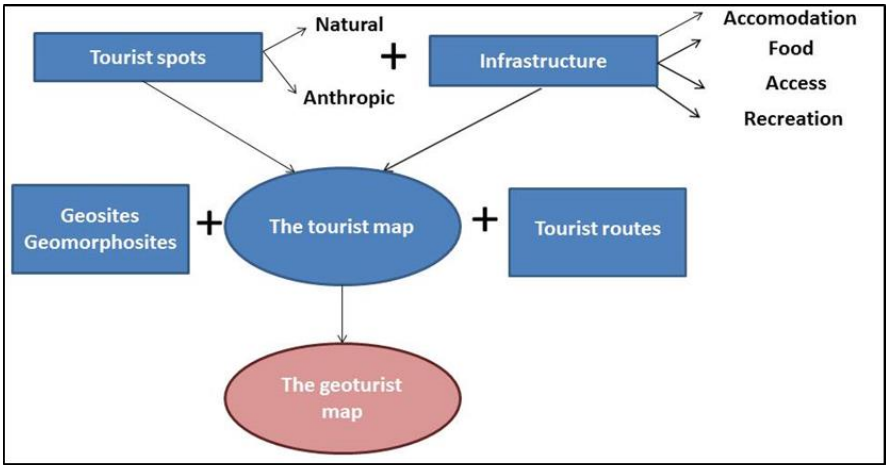

Figure 3. The geotourist map- methodological approach

RESULTS AND DISCUSSION

Following the application of the previously described methodology, the geotourist map was created in the central part of the Ciucaș massif, where most of the objectives and infrastructure of tourist importance are located (Figure 4). The main elements included in it are: the access network (national roads, forest roads, paths with markings and panoramic paths), tourist infrastructure (for accommodation - chalets, campsites, parking, information points, slopes where you can practice skiing, cross-country skiing and rock climbing routes), elements related to the relief (geomorphosites, geomonuments, belvedere points, passes, isolated rocks, gorges, avalanche corridors), hydrographic elements (permanent and temporary hydrographic network, snow accumulations), types of vegetation (forest, junipers), natural protected areas, other types of elements (sheepfolds, isolated buildings).

Access is from all directions, the main route being represented by DN1A- Bucharest-Cheia-Braşov. From the northwest, the access is through the Târlungului valley to the Babarunca chalet in the localities of Întorsura Buzăului, Vama Buzăului, Valea Doftanei [11]. One notices the access by forest paths and marked trails, most of them entering the radiating valleys that fragment the massif.

The most important marked trails of the Ciucaș massif are: Cheia - Cheiței valley - Bratocea Pass - Bratocea Mountain - Tigaile Mici Mountain - Ciucaș Peak; Cheia - Buzoianul peak - Poiana Zăganu - Zăganu Mountain - Gropșoarele Mountain - Cheia, Cheia - Muntele Roșu – Valea Berii - Cheia; Cheia- Cheiței valley - Balaban Mountain-- Tigăilor Saddle - Ciucas Chalet - Ciucaș peak; Poiana Stânei - Valea Berii - Cheia; Vama Buzăului - Poiana Dălghiului - Mâna Dracului – Ciucaș peak; Babarunca – Poiana Tesla Valea Stânei Gorges- Stânei Sadlle; Poiana Stânei - Părăului Alb valley - La Răscruce [15].

The accommodation infrastructure is represented by chalets: Muntele Roşu Chalet (1,260 m altitude, camping, slopes for winter sports, permanent regime, the existence of a meteorological and a seismic station) and Ciucaş Chalet (1,595 m altitude, two buildings, permanent regime), to which are added several sheepfolds and forestry cabins. Geomorphosites and geomonuments (geomorphosites of great value) (Table 1) are the landforms of great value that acquire (scientific, aesthetic, cultural, economic) value through human perception and constitute the basis of geotourism development. For this purpose, two routes were created: the subalpine route and the differential erosion route.

Table 1. The geomorphosites localized in the central area of Ciucaş Mts.

Name	Code	Origin	Type	Values	Route
Ciucaș Peak	BVmor01	Morphological	Punctual	Scientific, Aesthetic	Subalpine
Goliat Tower	BVed01	Differential erosion	Punctual	Scientific, Aesthetic	Subalpine
Bratocea Interfluves	BVmor02	Morphological	Area	Scientific	Subalpine
Babele la Sfat	BVed02	Differential erosion	Punctual	Scientific, Aesthetic	Subalpine
Tigăile Mari	BVed03	Differential erosion	Punctual	Scientific, Aesthetic, Cultural	Subalpine
Chirușca Intefluves	BVmor03	Morphological	Area	Scientific	Subalpine
Tigăilor Saddle	BVfl01	Fluvial	Punctual	Scientific, Aesthetic	Subalpine
Tigăile Mici	BVed04	Differential erosion	Punctual	Scientific, Aesthetic	Subalpine
Roșu Tower	PHed01	Differential erosion	Punctual	Scientific, Aesthetic	Subalpine
Albela Intefluves	PHmor01	Morphological	Area	Scientific	Differential erosion
Muntele Roșu Peak	PHmor02	Morphological	Punctual	Scientific, Economic	Differential erosion
Muntele Roșu Intefluves	PHmor03	Morphological	Linear	Scientific, Economic	Differential erosion
Gropșoarele-Zăganu Intefluves	PHkar01	Karst	Punctual	Scientific, Aesthetic	Differential erosion
Muntelui Roșu Needles	PHed02	Differential erosion	Punctual	Scientific, Aesthetic	Differential erosion
Gropșoarele Peak	Phmor04	Morphological	Punctual	Scientific, Aesthetic	Differential erosion
Triunghiular Tower	Phed03	Differential erosion	Punctual	Scientific, Aesthetic	Differential erosion
Căprioarei Tower	Phed04	Differential erosion	Punctual	Scientific, Aesthetic	Differential erosion

On each of these routes, in addition to the geomorphosites that can be observed (Table 1), a series of other information related to relief, vegetation cover and hydrography can be highlighted. For the most part, these routes correspond to sectors of existing tourist routes in the massif, with a series of deviations to include other objectives within them.

Figure 4. The geoturist map of Ciucaș Mts

CONCLUSION

The Ciucaș massif has numerous geomorphosites that are reduced or not included in the tourist activity, due to the lack of necessary information (lack of updated or complete cartographic materials, non-existence of information panels both in the Cheia resort and along some routes, deficient markings in certain points; flyers with a few and poor geotourism information). It is also necessary to adopt some legislative measures (declaring the natural protected areas) and structural measures (construction of fences, arrangement of paths) for the most important geomorphosites located in this area. The degree of protection is quite low in this area. Thus, the Ciucaș Mountains currently have protection status - SCI within the Natura 2000 network, but this primarily concern the ecosystems (existing species of flora and fauna). Among the geomorphosites, Tigăile is a protected natural area (category IV IUCN), by Law No. 5 of March 6th, 2000 and has an area of 3 ha, a set of forms of differential erosion, areas with alpine hollows, meadows and pastures, being protected.

Given the value of geomorphosites in this area, it is necessary to develop geotourism, which can also provide benefits to local communities. The present map is intended to be multiplied and transmitted to the competent local authorities, in order to carry out projects aimed at the development of this form of tourist at the level of the Ciucaș massif.

Acknowledgements

The contribution of authors is equal. We want to thank our colleague PhD student George Cosmin Păunescu for his support in accomplishing the graphical part of this article.

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THE INVENTORY AND EVALUATION OF GLACIAL AND PERIGLACIAL GEOMORPHOSITES. STUDY CASE – RETEZAT MOUNTAINS (SOUTHERN CARPATHIANS, ROMANIA)

DOI: https://doi.org/10.18509/GBP23035n
UDC: 551.435.4/.5.02(234.421.2:498)

Alexandru Nedelea
Laura Georgiana Comănescu
Geomorphology-Pedology-Geomatics Dept, Faculty of Geography, University of Bucharest, **Romania**

ABSTRACT

The primary purpose of this paper is the inventory and evaluation (by our method) of the most important glacial and periglacial geomorphosites in the Retezat Massif. Thus, 30 geomorphosites were analyzed, for which inventory sheets were drawn up and subsequently evaluated: scientific value – 20 points (paleogeographical interest, representativeness, rarity, integrity, degree of scientific knowledge, use in educational purposes, ecological value, diversity), aesthetic value -20 points (visibility, space structuring, color contrast, level difference, landscape framing), cultural value -20 points (cultural characteristics, historical characteristics, religious characteristics, iconographic/ literary representations, cultural manifestations, symbolic value), economic value – 20 points (accessibility, infrastructure, yearly number of visitors, number of types and forms of use, economic potential/income), management and use – 20 points (preservation degree, protected sites, vulnerability / natural risks, the intensity of use, the use of aesthetic, cultural and economic value, relationship with planning policies). The total weight is calculated as the sum of the geomorphosites values divided by 100 in order to be able to compare it with other existing methods in the specialized literature. The obtained values vary between 0.36 (Grohotiș scree) and 0.78 (Bucura glacial cirque), and 0.77 (Zănoaga glacial cirque).

Keywords: inventory, evaluation, geomorphosites, glacial, periglacial, Retezat, Southern Carpathians, Romania

INTRODUCTION

Geomorphosites are landforms that, thanks to human perception, receive a value that can be scientific, aesthetic, cultural and economic [11]. The study of geomorphosites dates back to the beginning of the 2000s, among the main objectives of the scientific community being: the realization of the theoretical design, the establishment of inventory, evaluation and mapping methodologies and ways of valorization.

The inventory consists in the identification of all geomorphosites in a particular area and their classification. There is no unanimously accepted methodology in the specialized literature. Thus, several geomorphosite inventory sheets were created; the most well-known belong to Pralong, 2005 [8] and Reynard, 2007 [10]. In the present study, for the selected geomorphosites, the inventory sheet from the work of [8] (with modifications) was used, a sheet that includes both qualitative and quantitative elements.

Since 2000, the evaluation of geomorphosites has been constantly at the attention of researchers, and numerous evaluation methods have been developed. These are different

from one geomorphological school to another, depending on the value assessed primarily (especially scientific), the targeted area and the purpose of the approach.
[9], [2], [3], [5] summarize the existing methods in the specialized literature, with each of them establishing strengths and weaknesses as well as the possibilities of use.
On the world level, two important period can be outlined in terms of evaluation methods: 2000-2009 (numerous methods appeared that generally targeted all geomorphosite values, applied for different geographical spaces) and 2009 - present (a lower number of methods appeared, more refined and which combine the quantitative and the qualitative side, including the management/use of geomorphosites).
In 2012, we proposed a new evaluation method, which was initially applied for the Ponoare protected natural area (all evaluated geomorphosites are karst landforms), and later, for the upper basin of the Argeș River (the evaluated geomorphosites having different origins: glacial, periglacial, karst, fluvial, tectonic etc.) [1], [4].
The own method used in these two studies has the main purpose of increasing the degree of objectivity of the evaluation, by introducing numerous different parameters (with clear scores and subscores) adapted to the Romanian Carpathian area [4].
To validate it, it is necessary to apply it in different geographical contexts where there are geomorphosites with varied typology and value. In order to achieve this approach, the present study is a continuation of the previous ones (2012, 2020) [1], [4]. Its general objective consists of evaluating the geomorphosites in an alpine area (the Retezat massif), where typical glacial and periglacial geomorphosites are located, some of them of great value at the national level.

STUDY CASE

The Retezat massif is located in the northwest of the Southern Carpathians (Romania), part of the Retezat-Godeanu Group, between Jiu, Strei and Danube (Figure 1). It is connected to the Godeanu Mountains, in the southwestern (via the Tulișa ridge) and to the Șureanu Mountains in the eastern and northeastern. They are bordered by depression areas with low altitudes (Hațeg at 300-400 m and Petroșani at 700-800 m), which they dominate through steep slopes.
Considering the variety and diversity of the geomorphological and hydrological landscapes, the complexity of the glacial and periglacial relief, the value of the elements of flora and fauna (over 1200 species, many of which are endemic), in 1935, it was declared the first national park on the territory of Romania, currently being a biosphere reserve. When it was established, the Retezat National Park had an area of 13,000 ha. Today, the site is 38,138 ha, and it is mainly located within the basins of Lăpușnicu Mare, Nucşoara and the right tributaries of the Râului Mare. Within the park, the scientific reserve (Zlata - Dobrun basin) stands out, with an area of 1,500 ha, where access is strictly limited [5], [7], [13].
In the Retezat National Park, there are 50 peaks over 2000 m, the highest being Peleaga – 2509 m, Păpușa – 2508 m and Retezat – 2482 m (with a unique aesthetic value due to its cut shape, which makes it visible and recognizable from a long distance) [13].
According to [6], the petrographic composition is represented by lithological formations belonging to the Danubian Autochthon and the Getic Nappes. The Danubian autochthon consists of granitoid eruptive massifs in the central part (such as Buta and Retezat), meso-metamorphic schists (quartzitic, mica schist, graphitic) located on the periphery and sedimentary deposits (in the southeast and north) containing limestone, conglomerates, sandstones. Getic Nappes has a relatively small extent and consists of ophiolites and

meso-metamorphic crystalline schists. All these rocks determine distinct geomorphological landscapes (on crystalline, the relief is massive, rough, heavy, and rounded; on the granite, sharp interfluves appear, with talus; on limestone, a relief develops with steep slopes and specific landforms), with important differences in terms of the morphology of glacial and periglacial landforms [5].

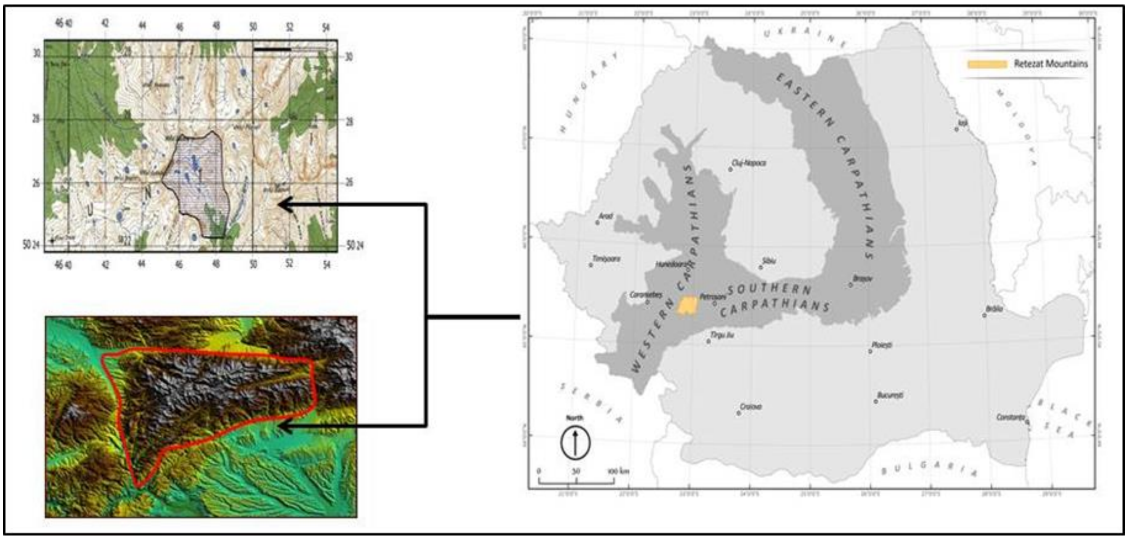

Figure 1. The geographic position of Retezat Mts in Romania

Its specificity is given by the presence of the most complex and representative glacial and periglacial geomorphosites in Romania. Next, we shall exemplify the most important types of geomorphosites from the previously listed categories [5] with modifications and additions [7, 12].

Glacial geomorphosites (Figure 2):

- glacial and glacio-nival cirques with different morphologies such as: Aradeşu I, II, Berbecilor, Buta, Bârlogul Ursului, Bârlea, Căldarea Pietroasă, Cioaca Radeșului, Ciumfu, Custura, Dobrunu, Fereastra Custurii, Galeşu, Groapele, Gemenele, Lia, La Clince, Judele, Obârşia Nucşoarei, Pustnicu, Pilugu, Pietrele, Peleaga, Peleguța, Păpușa, Radeșu, Răsucit, Slăveiu, Şesele, Stânişoara, Ștevia, Ştirbu, Țapului, Turcel, Tăul Negru, Văsiel, Valea Rea, Zănoaga, Zănoguța;
- glacial valleys with lengths measured in km, with a transverse U-shaped profile, and as examples we mention Aradeşu, Buta Mică, Buta, Cârligu, Dobrunu, Lăpușnicul Mare (developed by Judele, Bucura, Peleaga and Paltina valleys), Nucşoara (developed by Beagu, Galeşu, Valea Rea, Pietrele, Stânişoara valleys), Paroşu Mare, Peleaga, Radeşu Mic, Radeșul Mare, Râu Alb, Râul Bărbat (developed by Custura, Ciumfu, Gruniu, Lazăru, Văcarea valleys), Şesele, Ștevia, Zlătuia (developd by Scoaba Retezatului, Rovine, Tăului Negru, Ştirbu valleys);

Figure 2. The most important geomorphosites in the Retezat Mountains
(A- Zănoaga glacial cirque; B- Bucura glacial cirque; C- Galeșu glacial cirque;
D- Țapului glacial cirque; E- Peleaga Needles; F- Peleaga Peak)

- alignments of peaks and ridges/karlings (with lengths of more than 1 km) such as Retezat, Păpușa, Bucura, Zlata-Zănoaga, Slăveiu (contemporary, affected by periglacial system)
- the moraines of the valleys: Râul Mare, Râul Bărbat, Nucşoara, Pietrele, Judele, Ştevia;
- the glacial step with glacial knobs and striae, different in morphology depending on the rocks on which they were formed;

- the glacial saddles formed between cirques Galeşu and Valea Rea, Valea Rea and Peleaga, Valea Rea and Pietrele, Pietrele and Bucura, Pietrele and Stânişoara, Stânişoara and Ştevia, Ştirbu and Bucura;
- Periglacial geomorphosites (Figure 2):
- sharp peaks and ridges of different shapes, with steep slopes and different types of scree (needles or fangs: Pelegei Needles, Slăveiul Mare; towers: Porții Tower);
- corridors of avalanches with V profile and lengths in meters;
- micro depressions and snow niches;
- cones and talus, torrents of stones, masses of gelifracts;
- pronival rampart and glacier stone (in the valleys Judele, Știrbu, Pietrele, Valea Rea, Pietricele, Ana);
- cryoplanation surfaces;
- solifluction terraces and mounds;
- thufurs;
- stone pavements;
- block fields and stone circles;

METHODOLOGY

The proposed methodology aims to inventory, classify and evaluate the geomorphosites that have been selected based on the criteria of importance and representativeness. It starts from the selection from specialized literature and the field trip, in which geomorphosites will be located on the cartographic materials [1, 4].

Their inventory will be made based on the sheet used in the specialized literature (8), with modifications related to the area where it will be applied, later they will be classified according to several criteria: time, type, origin and importance.

The evaluation is carried out based on the criteria in table 1, and for the calculation of the total value the formula is applied: Vtot = (Vsci +Vsce +Vcult +Veco+Mg)/100 [1,4] where Vsci - the scientific value, Vsce - the aesthetic value, V cult - cultural value, V eco - economic value, Mg - management and use. For each sub-criterion, a score is given between 0 and the maximum value that can be given according to table 1.

For the scientific value, the evaluated sub-criteria are: paleogeographical interest (the existence of fossils/elements of value to show the evolution of the area), representativeness (the importance for the analyzed area), rarity (at the level of the analysis scale), integrity (affecting the geomorphosite by the current geomorphological processes), the degree of scientific knowledge (the presence of the landform / geomorphological process in the specialized literature, in different categories of papers), the use in educational purposes (the possibility or even the use as an example for pupils and students in practical field applications), the ecological value (existence of rare or protected species, other ecological characteristics) and diversity (for both geodiversity and biodiversity, if any) [1].

As part of the aesthetic value, the following are evaluated: visibility (the number of belvedere points towards the geomorphosites and the panorama it offers), the space structuring, the color contrast (the greater contrast means the higher value), the level difference (larger level differences increase the aesthetic value) and landscape framing (the mode of structure into the landscape) [1].

The cultural value is given by the following sub-criteria: cultural characteristics, historical characteristics, religious characteristics, iconographic representations (in literary works,

works of art, etc.), festivals /cultural manifestations (their importance and frequency are taken into account), symbolic value [1].
The economic value consists of: accessibility (how access is achieved and the distance from it), infrastructure (type of roads, paths, cable infrastructure, proximity to other types of facilities), the number of yearly visitors, number of types and forms of tourism (use in tourist activities through different types and forms of use), economic potential (if it is possible to calculate actual incomes) [1].
The management and use evaluates the following sub-criteria: preservation degree (how the geomorphosite suffers as a result of aggressive human activities), protected sites (natural protected areas), vulnerability / natural risk (natural and anthropogenic risks), the intensity of use (way, period and intensity of use), the use of the aesthetic, cultural or economic value (if there are forms of tourism or other activities of this type), relationship with the planning policies (the existence of strategies, projects, programs in which the geomorphosites are included) [1].

Table 1. The criteria and scores proposed for evaluating geomorphosites [1, 4]

Scientific value – 20 points	**Aesthetic value - 20 points**	**Cultural value - 20 points**	**Economic value - 20 points**	**Management and use - 20 points**
paleogeographic interest -3p	visibility – 4p	cultural characteristics -4p	accessibility -4p	preservation degree -4p
representativeness-2p	space structuring – 4p	historical characteristics -4p	infrastructure-4p	protected sites - 3p
rareness – 2p	colour contrast - 4p	religious characteristics - 4p	yearly visitors number -4p	vulnerability/ natural risks - 3p
integrity -2p	level difference- 4p	iconographic/ literary representations -2p	number of types and forms of use (inclusively touristic) -4p	the intensity of use - 4p
degree of scientific knowledge -3p	landscape framing- 4p	festivals/ cultural manifestations -2p	economic potential (incomes) -4p	the use of aesthetic, cultural and economic value -3p
use in educational purposes - 3p		symbolic value -4p		relationship with planning policies-3p
ecologic value-3p				
diversity-2p				

To ensure comparability with other methods, division by 100 is performed, so the total value will be between 0 and 1 (as with most other methods). To ensure an objective evaluation, all criteria have the same weight (20 points), with no reason for one of the values to receive higher total scores [1, 4].

RESULTS AND DISCUSSION

Following the application of the methodology described above, aimed at the selection, inventory, classification and evaluation of geomorphosites, a series of results summarized in tables 2, 3 and 4 were obtained. Thus, of the total of 30 selected geomorphosites, 56.67% are glacial and 43.33 % are periglacial. The weights are identical to those for the functionality criterion: 56.67% are passive (glacial geomorphosites formed during previous glacial phases, today they are modeled in the periglacial system), and 43.33% are active (periglacial geomorphosites resulting from the action of freeze-thaw processes, eolization, nivation, the action of rainwater, etc.). Regarding the spatial distribution of geomorphosites, their weight is 60% for areal ones (glacial cirques/complexes), 20% for linear ones (glacial valleys, ridges, etc.) and 20% for punctual ones (peaks and witnesses of erosion).

Table 2. – The glacial and periglacial selected geomorphosites from the Retezat Mts- classification and inventory

Name	**Code**	**Origin**	**Type**	**Functionality**
Zănoaga glacial cirque	HDgla01	glacial	area	passive
Bucura glacial cirque	HDgla02	glacial	area	passive
Tăul Negru glacial cirque	HDgla03	glacial	area	passive
Gemenele glacial cirque	HDgla04	glacial	area	passive
Pietrele glacial cirque	HDgla05	glacial	area	passive
Peleaga glacial cirque	HDgla06	glacial	area	passive
Galeșu glacial cirque	HDgla07	glacial	area	passive
Țapului glacial cirque	HDgla08	glacial	area	passive
Dobrunu glacial valley	HDgla09	glacial	linear	passive
Judele glacial complex	HDgla10	glacial	area	passive
Lăpușnicul Mare glacial complex	HDgla11	glacial	area	passive
Nucșoara glacial complex	HDgla12	glacial	area	passive
Bucura karling	HDgla13	glacial	linear	passive
Retezat saddle	HDgla14	glacial	area	passive
Lolaia saddle	HDgla15	glacial	area	passive
Peleaga saddle	HDgla16	glacial	area	passive
Judele saddle	HDgla17	glacial	area	passive
Grohotiș scree	HDper01	periglacial	area	active
Drăgșanului ridge	HDper02	periglacial	linear	active
Piciorul Peleaga ridge	HDper03	periglacial	linear	active
Peleaga needles	HDper04	periglacial	linear	active
Slăveiul Mare needles	HDper05	periglacial	linear	active
Peleaga peak	HDper06	periglacial	punctual	active
Custura peak	HDper07	periglacial	punctual	active
Bucura peak	HDper08	periglacial	punctual	active
Păpușa peak	HDper09	periglacial	punctual	active
Retezat peak	HDper10	periglacial	punctual	active
Rock glacier at Valea Rea	HDper11	periglacial	area	active
Rock glacier at Pietrele Valley	HDper12	periglacial	area	active
Porții Tower	HDper13	periglacial	punctual	active

Table 3. The sample structure of glacial and periglacial selected geomorphosites

		Absolute frequency	Relative frequency
Origin	Glacial	17	56.67
	Periglacial	13	43.33
Type	Area	18	60.00
	Linear	6	20.00
	Punctual	6	20.00
Functionality	Passive	17	56.67
	Active	13	43.33

The total value of the geomorphosites varies between 0.78- Bucura glacial cirque, 0.77- Zănoaga glacial cirque, respectively, 0.36 for the scree – Grohotiș (Table 4). The first geomorphosites are known nationally, within them, there are glacial lakes that hold national superlatives (the deepest – Zănoaga, respectively, the most extensive – Bucura) and present the most significant flows of tourists from this massif. The Grohotiș geomorphosite has the lowest value (the scientific importance is high, but the other values are low) and is poorly used from a tourist point of view.

Table 4. The assessment of glacial and periglacial selected geomorphosites

Name	Scientific value	Aesthetic value	Cultural value	Economic value	Management and use	Total value
Zănoaga glacial cirque	20	20	2	17	18	77/ 0.77
Bucura glacial cirque	20	20	2	18	18	78/ 0.78
Tăul Negru glacial cirque	18	18	0	10	14	60/ 0.60
Gemenele glacial cirque	19	20	1	10	14	64/ 0.64
Pietrele glacial cirque	19	19	0	10	12	60/0.60
Peleaga glacial cirque	20	20	0	14	15	69/0.69
Galeşu glacial cirque	19	20	0	12	17	68/0.68
Țapului glacial cirque	19	19	0	9	14	61/0.61
Dobrunu glacial valley	18	19	0	10	13	60/0.60
Judele glacial complex	20	19	0	12	15	66/0.66
Lăpușnicul Mare glacial complex	20	20	1	14	15	70/0.70
Nucșoara glacial complex	19	20	0	12	14	65/0.65
Bucura karling	19	20	1	12	12	64/0.64
Retezat saddle	18	18	0	9	11	56/0.56
Lolaia saddle	17	16	0	9	10	52/0.52
Peleaga saddle	18	18	0	8	11	55/0.55
Judele saddle	17	17	0	8	10	52/0.52
Grohotiș scree	13	9	0	7	7	36/0.36
Drăgșanului ridge	14	14	0	11	9	48/0.48
Piciorul Peleaga ridge	14	14	0	11	10	49/0.49
Peleaga needles	17	18	0	10	12	57/0.57
Slăveiul Mare needles	16	18	0	10	12	56/0.56
Peleaga peak	17	20	1	12	13	63/0.63
Custura peak	17	19	0	10	11	57/0.57
Bucura peak	16	20	1	11	12	60/0.60
Păpușa peak	17	18	1	11	12	59/0.59
Retezat peak	17	20	2	12	13	64/0.64
Rock glacier at Valea Rea	15	9	0	7	7	38/0.38
Rock glacier at Pietrele Valley	15	9	0	7	7	38/0.38
Porții Tower	16	16	1	10	10	53/ 0.53

The scientific value of the selected geomorphosites is very high. They are located in the first protected natural area of Romania - the Retezat National Park, where the most typical and complex glacial and periglacial geomorphosites are considered to be located. They also have a significant didactic value, being present in school textbooks and university courses or in some field applications in geography study programs. Thus, the maximum

value (20p) was given to the following geomorphosites: Zănoaga glacial cirque, Bucura glacial cirque, Peleaga glacial cirque, Judele glacial complex, Lăpușnicul Mare glacial complex, and the one with the lowest value (13p) was evaluated to be Grohotiș scree (Table 4).
The aesthetic value is also high, being included between 20 points (Zănoaga glacial cirque, Bucura glacial cirque, Peleaga glacial cirque, Lăpușnicul Mare glacial complex, Nucșoara glacial complex, Bucura karling, Peleaga peak, Bucura peak, Retezat peak) and 9 points (Grohotiș scree, Rock glacier at Valea Rea, Rock glacier at Pietrele Valley). High values are recorded either by glacial complexes impressed with numerous landforms or lake units, by ridges with a special morphology that also have a panoramic function, or by peaks that are important belvedere points or have a special shape (such as the Retezat peak) (Table 4).
The cultural value was evaluated with reduced scores between 0 and 2 points (Zănoaga glacial cirque, Bucura glacial cirque, Retezat peak), there being no elements of cultural, historical, religious or symbolic importance related to this area (Table 4).
The economic value presents the average importance at the national level, the assessment is carried out with considerable difficulty due to the lack of clear data related to the number of tourists/year or the income obtained from tourist activities. The points awarded to these sub-criteria are standardized for the entire area. Also, accessibility is relatively difficult for all geomorphosites, only the different categories of marked paths are able to reach them. According to this criterion, the points awarded vary between 18 (Bucura glacial cirque) and 7 (Grohotiș scree, Rock glacier at Valea Rea, Rock glacier at Pietrele Valley) (Table 4).
For management and use, the points awarded are between 18 (Bucura glacial cirque, Zănoaga glacial cirque) and 7 (Grohotiș scree, Rock glacier at Valea Rea, Rock glacier at Pietrele Valley). These values are related to the presence of the Retezat National Park, the degree of high protection of many areas but also of the existence of natural risks (avalanches, rock falls, etc.) Apart from the Retezat National Park management plan, there are no projects/policies related to territorial planning and local development (Table 4).

CONCLUSION

This method was applied for three case studies, namely: the Ponoare natural area (Mehedinți Plateau), the upper basin of the Argeş River (Southern Carpathians) and the alpine sector of the Retezat massif (Southern Carpathians).
For the first case study, karst geomorphosites were selected, and their total value varied between 0.75 (Ponoare Natural Bridge) and 0.35 (Ponoare Sinkhole Field) [1].
In the research related to the upper basin of the Argeș River, the chosen geomorphosites are varied in origin (glacial, periglacial, fluvial, tectonic, etc.) their values varying between 0.75 (Vânatorea lui Buteanu Peak) and 0.51 (Izvorul Moldoveanu Valley) [4].
In the present study, the geomorphosites selected are glacial and periglacial, and their total values vary between 0.78 (Bucura glacial cirque), 0.77 (Zănoaga glacial cirque), respectively 0.36 (Grohotiș scree).
It can be seen that the obtained values contribute to the validation of the method, the differences being relatively small and reflecting the specificity of the analyzed area. Thus, in the first case, the reduced values are due to the difficult access to the area, the lack of adequate infrastructure and promotion. In the second case, the higher scientific value is noted, to which is also added the accessibility achieved through cable transport or the

Transfăgărașan national road, as well as the high degree of knowledge the population has about them and from the specialized literature.
In the present work, geomorphosites have a great value in terms of the aesthetic and scientific point of view. The economic value, management and use are average compared to the other case studies, but the cultural value is the lowest. These data are highlighted by the average of the points awarded by value categories for the 30 geomorphosites, obtaining: scientific value - 17.46, aesthetic value - 17.56, cultural value - 0.43, economic value -10.76; management and use value - 12.26.
In the future, it is necessary to choose some areas from the Carpathian with varied lithology, structure and tectonics, as well as with other types of relief such as: volcanic, fluvial and petrographic..

Acknowledgements
The contribution of authors is equal. We want to thank our colleague PhD student George Cosmin Păunescu for his support in accomplishing the graphical part of this article.

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SECTION

SOCIO-ECONOMIC GEOGRAPHY

ADVANTAGES OF IMPLEMENTATION OF C6ISR IN LOW BUDGET ARMIES

DOI: https://doi.org/10.18509/GBP23047p
UDC: 355.41.078.3-048.22

Aleksandar Petrovski[1]
Marko Radovanović[2]
Aner Behlic[3]
Sofija Ackovska[4]
[1]Military academy "General Mihailo Apostolski", Skopje, North Macedonia,
[2]Military Academy University of Defence in Belgrade, Serbia,
[3]Armed Forces of Bosnia and Herzegovina: Travnik,
[4]Army of North Macedonia, Skopje,

ASTRACT

The implementation of a Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) system in armies with low budgets has become a topic of increasing interest in recent times. This paper delves into the various advantages of such implementation, with an emphasis on its significance in modern warfare. The work starts off by providing a clear definition of C6ISR and goes on to explain the different components that makeup such a system and how they contribute to the gathering and distribution of information.
In addition, the paper will explore the benefits that come with the implementation of a C6ISR system in low-budget armies, such as improved situational awareness, more effective decision-making, and the ability to better coordinate and communicate among units. Furthermore, the paper will also touch on the potential cost savings that can be realized through the implementation of C6ISR.
Finally, the conclusion will underscore the importance of C6ISR in today's warfare, and the importance for low-budget armies to invest in such systems so that they are able to compete effectively on the battlefield.

Keywords: C6IRS, army, battlefield, warfare, information

INTRODUCTION

In years, there has been a significant improvement in combat activities and where the application of scientific and technological achievements greatly improves the efficiency and effectiveness of recent units. Modern combat operations require the use of the most sophisticated combat means to effectively carry out the assigned missions. In order to effectively perform modern combat operations, it is necessary to apply state-of-the-art command and information systems with the aim of collecting, analyzing and visualizing data from the battlefield in real time, in order to facilitate and speed up the process of making timely and correct decisions for commanders (decision makers). The application of various combat systems integrated into the C6ISR system creates conditions for visualization of the battlefield in real time with cyber protection of the system, which allows commanders to command forces in a timely and efficient manner during the execution of operations. C6ISR stands for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance and is an upgrade to C4ISR and C5ISR systems. The complexity of the C6ISR system directly affects its economic characteristics, which has led to these systems being poorly or almost announced in countries with a small military budget.

The paper presents various advantages of the implementation of the C6ISR system in the armed forces with a focus on the importance of the application of this system in modern military operations. The concept of the C6ISR system with its components is defined and the significance of these components in the collection and distribution of information and data is shown. It also shows the advantage stipulated by the implementation of the C6ISR system in low-budget militaries, as well as the possible cost savings by implementing this system.

LITERATURE ANALYSIS

In the next part of the paper, an analysis of the available literature was carried out. Petrovski and Toshevski [1] show the application of GIS in geo-reconnaissance and C4IS for military purposes. Petrovski and Radovanović [2] analyze the use of drones in cooperation with the C4IRS system for the needs of the army. Bares [3] performs interoperability modeling for the C4IRS system in the collective security system. Radovanovic et al. [4] analyze the possibility of implementing drones in mortar units in order to increase the efficiency of fire support units by applying a fire management system in cooperation with the C4IRS system. Petrovski et al. [5] analyze the application of GIS in cooperation with the C4IRS system in geography for the needs of the military. Horizon Global Partners develops platforms that support C2, C3, C4, C5, C6 - ISR systems.[6] Halkis and Adha [7] analyze the C5ISR data link model of national defense in the face of cyber threats. Michaelis [8] analyzes explanatory systems to support IoT-based C5ISR applications on the battlefield. Wrzosek [9] analyzes the challenges of modern command and future military operations. Petrovski et al. [10] analyze the application of artificial intelligence drones for military purposes, where they explain the integration of drones into the C5ISR system. Radovanović et al. [11] They show the role of unmanned ground platforms in the protection of infantry units in the attack operation, where these platforms are integrated into one of the command and information systems C4-C6ISR. Svendsen in the chapter [12] Intelligence, Surveillance and Reconnaissance book Routledge Handbook of Defence Studies - analyze Intelligence, Surveillance and Reconnaissance (ISR) Integrated with C4, extending development to C4ISR, ISTAR and C4ISTAR.

MATERIALS AND METHODS

In the modern world, the possibility of applying command and information systems C6ISR is possible in various social areas, primarily in the military, and it is possible to apply them to other state administrations and local self-governments, in industry, trade, architecture, as well as for various international organizations.

Planning, organizing, and carrying out any modern combat operation cannot be well executed without information about the enemy, time and space, which can be collected using various surveillance and data collection systems. Supporting a modern soldier to achieve the success of a battlefield mission characterized by the use of sophisticated means requires reliable and professional real-time experience. [13] In the world, the need for the use of drones as one of the most important combat systems is growing with the aim of increasing the efficiency of military units. By applying [14] combat assets integrated into C4ISR, C5ISR and C6ISR systems, it is possible to have a real-time image from the battlefield, which gives the decision maker the ability to timely and effectively command and lead forces in combat operation.

Overview of the history and development of C6ISR system

In order to be able to talk about the concepts C4ISR, C5ISR and C6ISR it is necessary to define and explain the initial concept of C2 (Command and Control), because C2 is the starting point and base for the development and use of C4ISR, C5ISR, C6ISR. In order to effectively carry out the task, Command and Control involves the realization of a large number of different activities. The U.S. Department of Defense defines Command and Control as the management and exercise of authority by a commander (decision-maker) over forces in an operation to accomplish a mission. In order for a commander to make a timely and correct decision, it is necessary that the Command-and-Control system provide him with the necessary information that will lead to the success of the mission. Command and Control processes are characterized by three basic areas:

- Information management, i.e., collecting accurate and timely information necessary for the commander in the decision-making process;
- Managing decisions of commanders whose decisions are based on accurate and timely information collected; and
- Execution management, or different m departments of conducting activities by the army and the commander based on decisions made.
-

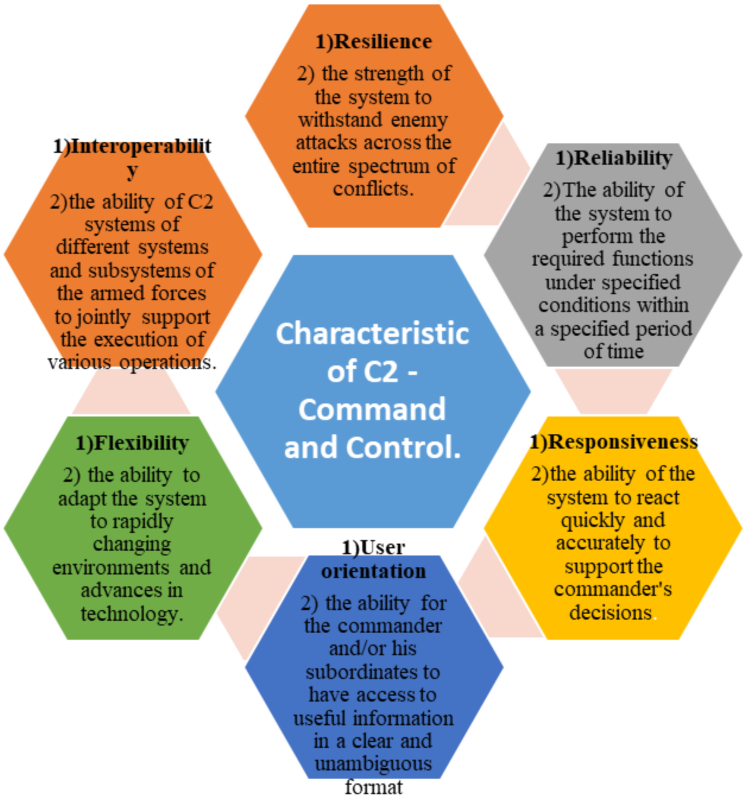

Figure 1. Features of System C2 – Command and Control

The development of science and technology has conditioned the need for more modern and efficient systems that have been developed and upgraded to the basic Command and Control system. Figure 2 shows the development of command and information systems.

Communications, facilities, equipment, human resources, and procedures that lead to the success of the mission, a combination of technologies and practical actions that provide information and support C2 processes implemented by commanders and the military make up the C2 system. The basic characteristics of the C2 system are shown in Figure 1. The main purpose of all command and information systems from C2 to C6ISR is to provide sufficient information to commanders in real time so that they can effectively command forces during operations.

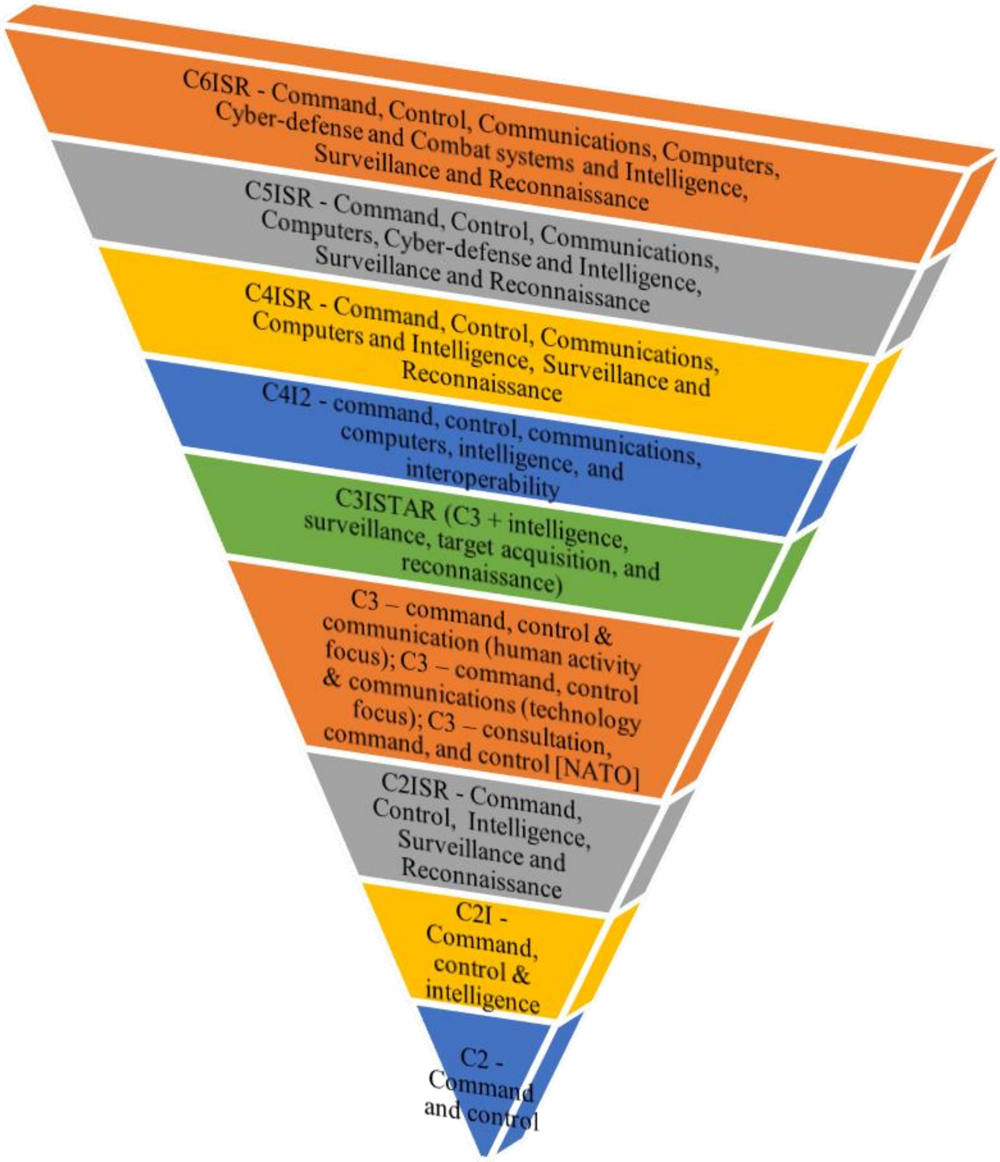

Figure 2. Development of command and information systems.

In further work, C4ISR, C5ISR and C6ISR systems are defined. As shown in Figure 1, C4ISR is an acronym that represents an upgrade to the concept of Command and Control by joining communications and computers. This command and information system implements facilities, equipment, manpower and various procedures and it has the designation C4 (Command, Control, Communications, Computers), and the addition of

ISR (Intelligence, Surveillance and Reconnaissance) includes all measures, actions and activities of collecting military intelligence in cooperation with C4.
C5ISR is an acronym for (Command, Control, Communications, Computers, Cyber-defense, Intelligence, Surveillance and Reconnaissance) where a cybersecurity system was added, while the implementation of combat systems in the C6ISR system improved the existing C5ISR. The only significant difference between the above-mentioned command and information system is the addition of equipment, manpower and procedures related to computers, cybersecurity and combat systems.
The best examples of C4ISR, C5ISR, and C6ISR systems are command and control facilities, where there is no typical example of a C4ISR, C5ISR or C6ISR system, because each military system includes a multitude of different facilities, equipment, personnel and procedures unique to their application, environment and mission.
C4ISR system example: Command and control point with internet connection, servers and workstations connecting to subordinate units, infantry, armored combat vehicles, aircraft, air defense systems and reconnaissance units that will collect information about the operating environment.
The C5ISR system constitutes a Command-and-Control Point with systems and assets such as the C4ISR with implemented cybersecurity defense system with security software that enhances the protection of the existing operating system and storage units and supports the intelligence, control and reconnaissance activities of subordinate units (systems).
The practical application of the C6ISR system is very diverse and can be seen in various military operations as well as in different civilian sectors. C6ISR can be practically applied:
In military operations where C6ISR systems are used to collect, process, and analyze information that is essential for decision-making. This includes monitoring the movements of enemy forces, monitoring weather conditions, identifying friendly and enemy forces, detecting minefields and other tasks. During the wars in Afghanistan and Iraq, the U.S. military used C6ISR systems to track enemy forces' movements and gather intelligence.
C6ISR systems can also be used for border surveillance to prevent illegal immigration, drug smuggling, terrorism, and other threats. The systems include surveillance cameras, radars for detecting enemy aircraft and drones, motion detection sensors, facial recognition software and other tools.
In civil protection to help with natural disasters (floods, fires, earthquakes, etc.) to monitor the situation on the ground, aid vulnerable residents and reduce the risk to people. Systems include drones, cameras, sensors, data processing systems and other tools.
In transport, it is used to track the movement of vehicles, manage traffic, monitor the fleet, and reduce the number of traffic accidents. The systems include GPS devices, vehicle detection sensors, route planning software and other tools.
One example of the use of the C6ISR system is the combat information center on a warship with all the systems and assets possessed by the C5ISR system and all support the defense system with the possibility of using the combat system itself.[15]
These examples show a wide range of applications of C6ISR systems in different sectors and their importance in increasing efficiency, speed and accuracy of decision-making.
It is very easy to find different models of C4ISR, C5ISR and C6ISR systems on the market today, because the market is driven by factors such as the increased use of geospatial intelligence as well as a change in the way of conducting combat operations where the

time required to carry out tasks is reduced, and the demands for displaying images from the battlefield in real time are growing, and examples of asymmetric warfare are increasing. Display and awareness of the current situation, analysis of enemies and environment, short time between detection and response are all the important features and advantages of modern C6ISR capabilities.
The C6ISR system has also found its application in modern combat operations on the territory of Ukraine, where it is used to enable rapid exchange of information and coordination among military forces and thus increase the operational efficiency and effectiveness of military operations. Various sensors, radars, thermal imaging cameras, communication systems and data analysis are integrated into this system, to obtain a complete picture of the situation on the ground. Bagira project is one of the examples of the application of the C6ISR system.

Explanation of the components of a C6ISR system and their functions
Command is the management center of the system and is responsible for making strategic decisions and planning operations. It includes commands, procedures and processes needed to manage and control military operations and field activities. The command component of the C6ISR system includes software and hardware tools that allow military commanders to gather real-time operation information by analyzing them for timely decision-making. It enables communication and coordination between different units and military command centers in order to effectively manage the forces. It consists of various tools such as: computer networks, command-leading software, operation planning software, as well as various sensors for data collection and processing. These tools are interconnected and integrated to enable rapid collection, analysis, and transfer of information between different units and command centers.
The Control component of the C6ISR system is an element that enables the control and management of various systems in the C6ISR system. It consists of software and hardware tools that enable the management of sensors, communication systems, data processing, as well as other systems and technologies used in the C6ISR system. It enables rapid management and control of various systems in real time as well as the collection and processing of data from those systems. It enables rapid detection and response to problems in the operation of various systems, to ensure the continuous operation of the C6ISR system. The key elements of the Control component of the C6ISR system are management, diagnostic and monitoring software, as well as hardware devices such as sensors and communication systems. These tools allow commanders to manage and control various systems in the C6ISR system in real time to ensure the success of the operation.
The communication component of the C6ISR system is a key component that enables efficient communication between the various units included in the C6ISR system. It consists of software and hardware tools that allow different units to communicate quickly and reliably with each other as well as with command centers and other elements of the system. It enables the application of various forms of communication, including voice communication, data transmission, video transmission and other forms. It provides the ability to deploy a variety of communication channels, including satellite, radio, optical and other channels, to ensure reliable and secure communication in different conditions and environments. It includes various sensors and devices for signal collection and transmission, as well as signal processing and analysis software for controlling and managing communication channels. They enable the rapid and efficient transfer of

information between different units as well as between units and command centers, which is crucial for the effective management of military operations.
The computer component enables rapid processing and analysis of data collected from various sensors in the system. It includes hardware and software tools that enable the collection, storage, analysis, visualization and sharing of data to provide useful information that supports real-time decision-making. It enables the use of various technologies for data processing, including artificial intelligence, machine learning, signal processing and others. This component enables the use of various data analysis software, including data visualization applications, data analysis applications, databases, and others. They enable fast and efficient real-time data processing to effectively manage military operations.
The cyber defence component of the C6ISR system is intended to protect the system from cyberattacks and other security threats. It has hardware and software tools that enable the detection, prevention and response of cyberattacks and other security threats. It enables the use of various technologies and approaches to protect the system from cyberattacks. It uses antivirus programs, firewalls, IDS/IPS systems and other applications. Enables the use of various hardware solutions for network protection, including security routers, switches, intrusion detection devices, secure information exchange systems, etc. These tools enable effective protection of the system from cyberattacks and other security threats.
The combat element of the C6ISR system includes a variety of hardware and software tools that enable effective management and coordination of military forces including planning, conducting, and controlling combat operations. It enables the use of various technologies and tools to conduct combat operations, including communication systems, navigation devices, sensors, cameras as well as other hardware and software tools. It enables effective communication and coordination between military forces, which includes infantry, tanks, aircraft, helicopters, ships, etc. These tools enable effective management of military forces, which includes quick response to changes in the environment, efficient use of available resources and quick decision-making.
The intelligence component of the C6ISR system is an element that collects, analyzes, and interprets data that is vital to the management of military operations. It consists of hardware and software tools that allow data to be collected from a variety of sources, including sensors, satellites, drones, and other sources of information. It also uses artificial intelligence, machine learning, analytical tools, and the like. This component collects data on enemy forces, terrain, weather conditions and other factors that are essential for planning military operations. It contains data collection sensors, satellite devices, drones, data processing software, data analysis applications, and data visualization tools. These tools enable fast and efficient data processing, in order to provide useful information to support the decision-making process in military operations.
The surveillance element of the C6ISR system refers to a set of technologies, processes and procedures used to monitor and collect information about various activities and situations on the ground in order to maintain security, prevent crime or unauthorized activities as well as for the purposes of military operations. It consists of various sensors, radars, cameras, drones, satellites and other technologies that are used to collect data on movements, locations, identities and other information relevant to the success of a military operation These tools enable efficient and accurate data analysis, enabling rapid recognition and response to activities that pose a threat or risk.

The Reconnaissance component of C6ISR refers to a set of technologies, processes and procedures used to collect, process, and analyze intelligence data to identify and identify potential threats, targets, or targets. It is used to collect and analyze information about enemy forces, territory, surroundings, as well as other factors that influence the successful conduct of military operations. This includes the use of various sensors, radars, satellites, drones and other technologies to collect data on enemy forces, as well as analyze that data to identify their intentions, activities and locations. This component is crucial for planning, conducting tactical and strategic operations, as well as for risk assessment and decision-making. They are used for identifying and analyzing potential threats, as well as for assessing the possibilities of performing successful operations under different conditions. Key elements of this component include various sensors and radar systems, data analysis tools, applications for identifying patterns and identifying threats, as well as other hardware and software tools. These tools enable efficient processing and analysis of intelligence data, which enables quick identification and identification of potential threats, targets, or targets.

RESULTS

The result of this study is a study that lists the advantages and positive characteristics of the application of the C6ISR system in low-budget armies. The development and application of C6ISR technologies that improve the military capabilities of small-budget militaries, including improving their situational awareness, communication capabilities and decision-making process, is explained. It also lists the advantages that C6ISR provides when conducting military operations, a way to increase efficiency and reduce costs over the long term.

Advantages of C6ISR in Low Budget Armies

The utilization of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) systems has become a paramount factor in modern warfare, especially for military forces operating with limited budgets. These systems offer a means of gathering, processing, and disseminating information quickly and accurately, ultimately providing soldiers with improved situational awareness and more effective decision-making capabilities. For armies with tight financial constraints, C6ISR systems represent a way to overcome resource limitations through increased efficiency and effectiveness on the battlefield.

In this chapter, we'll delve into the numerous benefits of implementing C6ISR systems in low budget armies, specifically in the Balkan regions. We'll examine the critical components that make up these systems, as well as how they contribute to information gathering and distribution. By exploring the advantages of C6ISR, such as heightened situational awareness, improved decision-making processes, and enhanced coordination and communication among units, we'll paint a picture of the positive impact these systems can have. Furthermore, we'll touch on the cost-saving benefits that come with implementing C6ISR and emphasize the importance of investing in these systems for successful competition on the battlefield.

The Impact of C6ISR on Situational Awareness and Decision-Making

The advantages of implementing a Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) system in low budget armies are numerous. These advantages include improved situational awareness and decision-making, better coordination and communication among units, and an increase in competitiveness on the battlefield. One of the key benefits of C6ISR is the improvement in situational awareness. Soldiers equipped with this technology have access to real-time information from various sources, including drone footage, surveillance cameras, and intelligence reports. This information is processed and analyzed by the C6ISR system, allowing soldiers to make informed decisions quickly and effectively. Studies have shown that soldiers who use C6ISR have a 40% improvement in situational awareness compared to those who do not. [16]

Another advantage of C6ISR is the improvement in coordination and communication among units. Real-time information sharing allows soldiers to understand each other's positions, movements, and plans, leading to better coordination and faster communication of important information. Research has shown that soldiers using C6ISR have a 50% improvement in their ability to coordinate and communicate with other units.[16] The implementation of C6ISR systems in low budget armies also results in improved competitiveness on the battlefield. Soldiers equipped with improved situational awareness and decision-making, as well as better coordination and communication, are better equipped to respond to changing situations and outmaneuver opponents. Additionally, C6ISR systems can help to reduce casualties as soldiers have access to real-time information that informs their actions and decisions. Research has shown that soldiers who use C6ISR have a 30% improvement in competitiveness compared to those who do not. [16]

Another study by the US Department of Defense (DoD) also found that C6ISR systems helped units communicate and coordinate more effectively in complex battlefield environments. [17]

Table 1. Overview references for advantages

Advantages	**Relevant study**
Improved Situational Awareness	Evaluation of Soldier Situational Awareness with a Tactical Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) System [16]
Better coordination and communication among units	Evaluation of Soldier Situational Awareness with a Tactical Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) System [16]
Improved competitiveness on the battlefield	Evaluation of Soldier Situational Awareness with a Tactical Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) System [16]
Improved situational awareness and decision-making	The Impact of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) Systems on Battlefield Outcomes [17]
Better coordination and communication among units	The Impact of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) Systems on Battlefield Outcomes [17]
Improved competitiveness on the battlefield	The Impact of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) Systems on Battlefield Outcomes [17]

The implementation of C6ISR in low budget armies has the potential to greatly improve situational awareness, coordination and communication, and competitiveness on the battlefield. The studies mentioned above [16,17] demonstrate the effectiveness of C6ISR in improving these areas and provide evidence of the benefits that low budget armies can reap from adopting this technology.

Cost effectiveness C6ISR

The use of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) systems can result in significant cost savings for military forces, particularly those with limited budgets. The ability to gather and analyze data in real-time can help reduce operational costs, while the improved situational awareness and decision-making enabled by C6ISR can reduce the need for costly resources like manpower and equipment. Study done by the Rand Corporation found that C6ISR systems can reduce the need for ground forces in certain operations, as the improved situational awareness enables more effective decision-making and reduces the risk of friendly fire incidents. This can result in significant cost savings for military forces, as fewer ground troops are needed, and less equipment is required for support. [18]
Another study by the US Department of Defense (DoD) found that C6ISR systems can help reduce the cost of intelligence gathering and analysis, as the technology can automate many of the tasks previously performed by humans.[17] Additionally, the ability of C6ISR systems to integrate data from various sources can result in more efficient use of resources, as decision-makers have access to a more complete picture of the battlefield. [19] In terms of equipment costs, C6ISR systems can help military forces make better use of existing resources, reducing the need for costly replacements or upgrades. For example, the improved situational awareness enabled by C6ISR can help military forces make better use of existing equipment, reducing the need for expensive replacements or upgrades. Additionally, the ability of C6ISR systems to integrate data from various sources can result in more efficient use of resources, as decision-makers have access to a more complete picture of the battlefield.[19] Furthermore, C6ISR systems can also reduce the cost of training and personnel, as the technology enables more effective and efficient training. For example, soldiers can be trained in the use of C6ISR systems in simulation environments, reducing the need for costly live training exercises [19].

Table 2. Overview references for advantages

Advantages	Relevant Study
Integration of multiple technologies into one system	Integrating C4ISR Systems for More Effective Joint Operations [16]
Reduction in equipment and personnel costs	The Cost-Effective C4ISR Revolution [20]
Increased efficiency and speed in decision-making	The Impact of C4ISR on Military Operations and Budgetary Savings [21]
Improved accuracy and reliability of data	C4ISR Integration and the Future of Warfare [19]
Minimization of duplication of efforts	Maximizing Cost Effectiveness in C4ISR Systems [22]

In conclusion, the use of C6ISR systems can result in significant cost savings for military forces. By improving situational awareness and decision-making, reducing the need for ground troops, automating intelligence gathering and analysis, making better use of existing equipment, and enabling more effective and efficient training, C6ISR systems can help military forces operate more efficiently and effectively, reducing the need for costly resources.

DISCUSSION

The implementation of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) systems in low budget armies presents numerous hurdles that must be surmounted to guarantee a successful deployment. These obstacles can be categorized into four critical areas: cost, training and education, equipment compatibility, and infrastructure:

- **Cost**: Cost is a major roadblock for low budget armies seeking to implement C6ISR systems. These intricate systems entail a massive investment in hardware, software, and personnel, which can prove to be a formidable challenge for armies with limited resources. [23] Furthermore, the cost of the systems is not limited to their initial investment - there are also recurring costs for maintenance, upgrades, and training.
- **Training and Education**: Low budget armies often struggle with providing training and education for soldiers to effectively operate C6ISR systems. These systems are complex and require a high level of technical expertise, and soldiers must be trained accordingly. This can be a daunting challenge for armies with limited resources, as providing such training can be resource-intensive. Additionally, the training must be continuous to keep soldiers up-to-date with the latest advancements in C6ISR technology.
- **Equipment Compatibility**: Ensuring compatibility with existing equipment is another challenge that low budget armies face in implementing C6ISR systems. These systems are often designed to work with other equipment, such as radios and sensors, but integrating them can prove to be difficult. This can lead to issues with data sharing, information dissemination, and overall operational effectiveness. In some cases, low budget armies may have to invest in new equipment or upgrade existing equipment to ensure compatibility, which can add to the cost and complexity of implementation.[24]
- **Infrastructure**: Infrastructure, including power and connectivity, can also pose a significant challenge to low budget armies implementing C6ISR systems. These systems require a reliable source of power and connectivity to other systems, such as command and control centers, to function effectively. This can be a major issue for low budget armies, as their infrastructure may be limited and upgrading it can prove to be challenging. In some cases, new infrastructure may have to be invested in or upgrades made to existing infrastructure to ensure the effective implementation of C6ISR systems.

Table 3. Overview references for challenges

Challenges	**Research Study**
Lack of funding for C6ISR technology	Budget constraints and challenges in the development and implementation of C6ISR systems [23]
Limited personnel and technical expertise	Challenges of Implementing C6ISR Systems in Low Budget Armies," Defense Industry Daily, June 1, 2021. [24]
Integration with existing systems and infrastructure	The Advantages and Challenges of Implementing C6ISR Systems, Defense Industry Daily, September 15, 2022. [25]
Maintenance and sustainment of C6ISR systems	Cost Savings Through the Use of C6ISR, Defense Industry Daily, October 5, 2022. [26]

Despite these challenges, low budget armies can still achieve a successful implementation of C6ISR systems with careful planning and a focus on cost-effectiveness. This may include selecting systems that are affordable and scalable, investing in training and education to equip soldiers with the necessary skills, and ensuring compatibility with existing equipment and infrastructure. [26] By adopting the right approach, low budget armies can overcome the challenges of C6ISR implementation and reap the rewards of improved operational effectiveness and increased situational awareness.

Discussion of current trends and innovations in C6ISR

The C6ISR system provides military units with an efficient and integrated capacity to collect, process and distribute information, enabling them to respond quickly and efficiently to challenges on the ground. Current trends in C6ISR systems include:

- Artificial intelligence and machine learning: Artificial intelligence and machine learning are increasingly used in C6ISR systems to automate information processing processes and improve assessment accuracy.
- Increased mobility: Mobile technologies and devices such as drones, smartphones and tablet computers allow military units to collect information from the field in real time.
- Sensor integration: A growing number of different types of sensors, including satellite imagery, unmanned aerial vehicles, field sensors and other technologies, are being integrated into C6ISRsystems to provide a hundred richer information about the field situation.
- Interoperability: interoperability between different C6ISR systems and units is key to the efficient operation of the system and the transmission of information between different units.
- Cybersecurity is becoming an increasingly important challenge for C6ISR systems, which is why technologies are increasingly entering into the development of technologies to protect against cyberattacks.
- Cloud computing when using C6ISR systems gain access to higher computer capacities and data storage, which enables fast processing and distribution of information.
- Greater efficiency and cost reduction have an increasing emphasis on efficiency and cost reduction leading to the development of technologies to optimize C6ISR systems and improve their efficiency.

Current innovations in C6ISR systems include the application of technologies such as 5G networks, wireless sensor networks, virtual and expanded realities and other technologies to provide even greater interoperability, efficiency and precision.

Possible solutions for smooth implementation

The integration of Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C6ISR) in frugal armed forces holds the promise of elevating situational awareness and enhancing decision-making processes, as well as fostering better communication and coordination among units. But this integration also presents a number of obstacles, particularly for forces with low budget constraints. These difficulties can stem from technical difficulties, such as compatibility and seamless integration, to financial and organizational hurdles. However, despite these difficulties, there are a plethora of feasible solutions that can alleviate the obstacles faced by low budget armed forces in incorporating C6ISR systems. One possible solution to technical challenges posed by C6ISR systems is the utilization of open-source software and hardware. Adopting open-source solutions enables frugal armed forces to cut down the costs involved in acquiring proprietary software and hardware, while also availing a wider range of customization and integration possibilities. Additionally, open-source solutions help tackle compatibility problems by being compatible with a diverse array of hardware and software platforms. A second solution involves creating partnerships and collaborations with various organizations and stakeholders. This can encompass partnerships between low budget armed forces and commercial technology companies, or collaborations between military organizations. These partnerships and collaborations can mitigate the limitations imposed by limited financial resources, and also offer frugal armed forces access to the most up-to-date technology and knowledge in the domain of C6ISR. A third solution entails adopting a phased implementation of C6ISR systems. This includes the initiation of the implementation with the core capabilities, such as intelligence gathering and situational awareness, and then progressively incorporating additional capabilities as resources and expertise become accessible. This approach helps manage the costs associated with implementation and reduces the risk of implementation failure. A fourth solution entails focusing on the development of local capabilities and expertise in the field of C6ISR. This involves investing in personnel training and development, as well as setting up research and development centers that specialize in C6ISR technology. By fostering local expertise, low budget armed forces can reduce their reliance on external organizations and suppliers and benefit from a more comprehensive understanding of the unique needs and requirements of their operations.

SUMMARY

Implementation of C6ISR systems in low budget armed forces presents several challenges, including technical obstacles, organizational limitations, and financial restrictions. Nevertheless, by adopting a combination of strategies, including the utilization of open-source solutions, creating partnerships and collaborations, adopting a phased approach, focusing on local capabilities, and embracing best practices and standards, low budget armed forces can overcome these difficulties and fully realize the benefits of C6ISR systems, including improved situational awareness, decision-making, coordination and communication, and competitiveness in the field of battle.

Low budget armed forces can gain from embracing best practices and standards in the implementation of C6ISR systems. This includes the utilization of established project management methodologies such as the Project Management Body of Knowledge (PMBOK), and the adherence to established technical standards such as those developed by the Institute of Electrical and Electronics Engineers (IEEE). By following established best practices and standards, low budget armed forces can guarantee the consistency and quality of their implementation processes and reduce the risk of implementation failure.

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MEDICO - GEOGRAPHICAL ANALYSIS OF DYSLEXIA AMONG CHILDREN IN BULGARIA

DOI: https://doi.org/10.18509/GBP23061v
UDC: 616.89-053.5:[911.3:314(497.2)

Neli Veselinova[1]
Liliya Yancheva-Velinova[2]
[1]Sofia University, Department of Social and Economic Geography, Faculty of Geology and Geography, Sofia, **Bulgaria**
[2] South-West University “Neofit Rilski”, Department of Speech therapy, Faculty of Public Health, owner of Amalteya Studio private practice, Sofia, **Bulgaria**

ABSTRACT

Dyslexia is a communicative disorder in which there is an inability to perceive and process the written form of speech through various sensory modalities. It is associated with difficulties in the process of processing information, which has an impact on the literacy process and is characterized by differences and inconsistencies between tasks and their implementation. The aim of the present work is to make a medico-geographic analysis of children with dyslexia in Bulgaria for the period 2010-2022. The medico-geographical research is significant in this case and connected with the school's geographical education. In addition to disorders in reading, writing, and mathematical abilities, students may have difficulties determining the geographical position of objects and locating them on the map, reading tables, and diagrams, describing phenomena and objects, etc., due to disorders in spatial orientation. Children with dyslexia are a category that requires a variety of knowledge from the geography teacher, including in the fields of medicine and communication disorders. In the present work, the number of children with dyslexia and their territorial distribution will be analyzed in the country and by districts. Specialists who work with children are few and it is necessary to be proposed a model in which children with dyslexia are covered by enough specialists..

Keywords: Bulgaria, medico-geographical analysis, dyslexia, geography

INTRODUCTION

Medico-geographic studies and analyzes in the field of child development are of particular importance. In Bulgaria, such analyzes are performed only by doctors or specialists in health care and work with children. Geography remains out of the process, and medical geography can be of significant help in solving complex health problems across the country. The need for specialists in places could be analyzed and qualitative planning could be made for the needs of the population and the future development of the territory through medical-geographic research and geographic information systems.

Geographers are interested in questions, pointed at theoretical issues and spatial models of medical geography [7], the vital need for geographical research in the development of some diseases in Bulgaria [1], [2], the specific language impairments, the problem with dyslexia, the necessity of oncogeography.

Dyslexia is within the scope of geography's scientific interest because children are society's most valuable priority. They must be well cared for and institutions and specialists must provide quality care for them. The problem arises when a particular disorder is detected in children and there is no specialist to help. Moreover, with the advancement of the child's age and with the introduction of the study discipline "Geography and Economics" after the age of 10-11, some difficulties are observed, related to orientation in the surrounding area, reading and analyzing geographical maps, map schemes, tables, diagrams.

Dyslexia is a complex problem and requires cooperation at different levels and of various specialists. Written speech, as a complex analytical-synthetic activity, develops based on oral speech and is a continuation of it [10]. Unlike oral language, reading and writing could only be acquired through special training, and literacy for Bulgarian children is after the sixth year. It is estimated that between 5-10% of children have disorders in the field of reading, writing, and/or mathematical operations and are dyslexic [3].

The term dyslexia was used for the first time in 1887 by the German doctor Berlin to denote isolated disorders in reading, in children with preserved intellectual functioning [3]. In 1968, the World Federation of Neurology gave one of the first definitions of Dyslexia, according to which it is a disorder manifested by difficulties in learning and reading, despite adequate conventional instruction, sufficient intelligence, and socio-cultural opportunities. Similar are the definitions of the International Statistical Classification of Diseases and Health Problems [ICD-10], of the World Health Organization [21] and the diagnostic criteria for the reading disorders of DSM-IV [11]. They describe learning difficulties as specific disorders in the development of school skills (F81). According to the specific content, the various disorders are divided into - a specific reading disorder (F81.0), which is designated as developmental dyslexia, a specific spelling disorder (F81.1), and a specific disorder of arithmetic abilities (F81.2) - dyscalculia [21].

THEORY AND METHODOLOGY

Dyslexia is perceived as a specific disorder of the ability to learn, a consequence of "a different type of information processing, which limits the development of literacy and leads to a discrepancy between expected and actual achievements in school" [16], [8]. In the clinical picture of the disorder, it manifests as a specific difficulty in spelling analysis, reading, and writing, and it is not necessary to observe disorders in all areas. Mathematical, musical, motor, and organizational skills could sometimes be affected. Spatial orientation in some individuals is impaired, which leads to additional problems in learning geography.

There are various theories that attempt to explain the etiology of the disorder. The first is the genetic theory, according to which there is a genetic predisposition to dyslexia, which varies between 32% and 62% [17], [15]. According to genetic studies, it is suggested that there are defects in chromosomes 1, 6, 15, and 18 [20].

Another theory is the phonological one, which is perceived as leading in the development of dyslexia. Developmental Dyslexia is commonly described as a language-based disorder in which phonological processing is often compromised [13].

Opposite to these theories of the etiology of dyslexia are the temporal, cerebellar (cerebellar and cerebellar-vestibular), and magnocellular theories.

According to the temporal deficit theory, the leading factor in dyslexia is the auditory deficit, and phonological problems are a result of the auditory deficit. It is thought that it is developed as a result of a disturbance in the processing of auditory information in the temporal zone [19].

The cerebellar theory was proposed by Nicolson and Fawcett [14] and is thought it is a result of delayed or dysfunctional articulation. Moreover, the difficulties that are often observed in mastering the corresponding grapheme-phoneme can be explained by the weak capabilities of the automatic control of articulation.

Cerebellar-vestibular theory, in turn, is based on the fact that the cerebellum integrates and regulates sensory impulses from receptors in the eye, ear, and proprioceptors, which can lead to poor visual-motor coordination [12].

Magnocellular theory brings together the theories, which were mentioned. According to it, deficits in dyslexia are due to a general difficulty in processing time. These general difficulties in the time required to process sensory information are related to the magnocellular system in the brain, whose pathways affect all sensory modalities [18].

Despite the existence of various opposing theories that explain dyslexia, all consider it as a multifactorial syndrome, an interaction between exogenous factors and the structural and functional characteristics of the central nervous system.

The purpose of this report is to analyze the medical-geographical situation in the frequency and prevalence of dyslexia in children in Bulgaria at the district level and to pay attention to the problem and specialists who take care of the children.

The object of the present study is children from 2nd to 12th grade who do not attend a special education school in Bulgaria. The data for this scientific article was provided by the Ministry of Education and Science in accordance with the Law on access to public information. Both individuals with dyslexia and professionals who care for children were examined. Dyslexia is diagnosed after the literacy process is complete, and the usual developmental errors are not allowed. We should note that, unlike other communication disorders, these children are covered by the education system, and the data cover the real number of children. Some of the children visit private therapeutic centers, where speech therapy, psychological and other services, including kinesitherapy, occupational therapy or ergo-therapy, and psychomotorics are included.

Methods which are used are the descriptive, statistical, method of analysis, and synthesis, historical and cartographic methods. First-grade children are not considered because the literacy process is not over, and the mistakes that could be made are part of the development.

RESULTS AND DISCUSSION

According to data from the last population census of Bulgaria, in 2021, the population in the age category 0-19 years is 1,312,173 people out of 6,838,937 people, or about 19.2% of the country's population. Education in geography at school starts in the 5th grade (children are around 10-11 years old). There are 349,723 children in this age category - 10-14 years, and 319,108 in the 15-19 age category. Children who are registered with learning difficulties and dyslexia in the country are 9,695 people, and these data include children aged 8-19. The relative share is not high, but the problems with the inability to cover all children with difficulties are visible.

The data of the National Statistical Institute [22], and the Ministry of Education and Science in Bulgaria [23], for children with dyslexia for the period 2010-2023 fluctuate widely (Table No. 1). The largest increase in registered cases was observed in the regions of Blagoevgrad, Varna, Vidin, Vratsa, Gabrovo, Dobrich, Kardjali, Kyustendil, Pazardzhik, Pernik, Plovdiv, Silistra, Sliven, Smolyan, Sofia - city, Sofia-region, Stara Zagora, Targovishte, Haskovo, Shumen and Yambol. In some of the districts, the increase in the number of children is not high, but in other places, more than a 2-3 times increase in the number of students with dyslexia is registered (Figure No. 1).

In the regions of Burgas, Veliko Tarnovo, Lovech, Montana, Pleven, Razgrad, and Ruse, a decrease in cases of dyslexia is noted. Some of the districts, although registering a decrease, it is with too few cases. This raises doubts about whether the parents recognize and seek help and a solution to the problem, or whether some of the families of these children migrate to larger cities in connection with the availability of better quality specialists. Another problem is the increasing illiteracy among students, without paying attention to possible difficulties, especially in small settlements far from urban centers. The periphery of the country is in deep crisis and the young people who live there do not have many opportunities. Specialists are missing or access to them is difficult. A significant problem that follows many others is the lack of information on issues related to dyslexia in children. With a shortage of healthcare professionals, there is often a shortage of teachers as well. If there are not good educators to notice a possible problem, even at a later age, the disorder deepens.

Figure 1. Mapscheme of the increase and reduction in cases of dyslexia by districts in Bulgaria, 2022
Source: National statistical institute; Ministry of education and science

Bulgaria has a well-developed system of speech therapy clinics. Initially, speech therapy assistance was provided within the "Speech Therapy Schools" or in an office in the "Special Schools" in the so-called "closed institutions". At the beginning of the democratic changes in the 1990s, speech therapy began to be deinstitutionalized and the "State Speech Therapy Centers" were set up, where children not only with communication disorders were admitted.

As reported by Mitova [4], [5], [6], the change in the attitude towards children with disabilities is slow and difficult, and only through the "National Program for the Development of School Education and Preschool Education and Preparation 2006 -2015" children with disorders have access to various specialists, not just speech therapy.

It can be seen from the data (Table No. 1) that the number of specialists in the country and by region has increased during the period. The number of speech therapists has increased about 4 times compared to 2010, psychologists - about 5 times, and special education teachers - about 2 times. This shows a good trend in the development of personnel and is part of the improvement of the population care and health care system. In reality, in the country there is no unified system for the quality of specialists and whether they improve their qualifications because they also work with other communication disorders.

In Bulgaria, one speech therapist works with 9 children, one psychologist - with 6.8 children, and one special education teacher - with 5 children (on average, for 2022-2023).

In 2022-2023, with the highest number of children and students with dyslexia is the city of Sofia. It is understandable and expected. The institutions are located there, and access to speech therapists, psychologists, and special education teachers is faster and easier. The fewest children are registered in the Kyustendil district. The reasons are many and varied, but some of the main ones are the aging population, the low birth rate, and the emigration of young people from the region (Figure No. 2).

There are about 8 children per speech therapist in the city of Sofia, 6,5 children per psychologist, and 5.4 children per special education teacher. There are good conditions for working with children with dyslexia in the city of Sofia, with indicators lower than the average for the country. In the Sofia region, there are about 10.5 children per speech therapist, but the city of Sofia is the educational center and many of the children in the region visit specialists in the city.

The Smolyan region is an example of a territory with a lack of specialists. There are 28.5 children per 1 speech therapist, 17 children per 1 psychologist, and 8 children per 1 special education teacher. Gabrovo and Vratsa districts also have deteriorated indicators. Is it possible for a speech therapist to work well and qualitatively with almost 30 children with dyslexia?

Specialists work with over 30 children with various disorders - motor, sensory, language and learning, and emotional-behavioral within 20 hours a week. It is necessary to create groups of children so every child could be covered. This reduces the quality of therapy.

Table 1. Reference for the number of children and students with dyslexia, studying in schools, kindergartens and centers for special educational support by districts in Bulgaria

№	District	2010/2011				2016/2017				2022/2023			
		Number of children and students with dyslexia	Number of specialists			Number of children and students with dyslexia	Number of specialists			Number of children and students with dyslexia	Number of specialists		
			Speech therapists	Psychologists	Special education teachers		Speech therapists	Psychologists	Special education teachers		Speech therapists	Psychologists	Special education teachers
	1	2	3	4	5	26	27	28	29	50	51	52	53
1	Blagoevgrad	184	28	10	36	346	39	20	52	495	55	50	63
2	Burgas	267	12	10	49	382	32	35	73	234	52	71	84
3	Varna	301	4	24	34	662	41	44	56	486	100	101	116
4	Veliko Tarnovo	243	14	9	31	365	17	24	42	231	35	53	51
5	Vidin	95	9	5	23	198	9	10	28	223	12	15	30
6	Vratsa	90	5	5	31	344	19	13	52	416	35	40	90
7	Gabrovo	61	6	6	10	120	11	12	16	143	12	18	28
8	Dobrich	178	8	6	14	257	14	10	20	247	28	29	42
9	Kardzhali	110	4	4	16	171	6	10	24	147	11	27	30
10	Kyustendil	63	7	3	20	176	9	6	26	77	12	15	26
11	Lovech	112	8	4	11	171	11	8	26	107	15	20	27
12	Montana	185	6	4	21	199	12	14	34	130	14	18	33
13	Pazardzhik	174	6	11	43	322	15	23	56	244	36	59	74
14	Pernik	155	2	3	20	234	8	9	32	185	18	23	49
15	Pleven	327	8	13	30	279	18	32	55	239	44	67	83
16	Plovdiv	335	20	15	58	383	29	36	65	351	66	116	122
17	Razgrad	207	0	9	29	189	7	10	34	122	14	22	34
18	Ruse	287	8	10	43	319	11	16	51	271	17	34	57
19	Silistra	149	3	3	21	224	10	9	34	219	20	25	51
20	Sliven	62	5	8	26	207	12	20	34	196	23	33	60
21	Smolyan	231	6	7	36	445	18	16	56	655	23	39	80
22	Sofia city	786	30	65	154	1591	133	138	165	2154	260	330	396
23	Sofia-district	73	7	3	0	183	11	11	8	283	27	33	37
24	Stara Zagora	215	10	11	53	542	15	22	50	620	48	68	118
25	Targovishte	285	4	4	28	404	8	14	42	406	21	25	56
26	Haskovo	273	2	7	42	375	27	13	47	406	29	40	53
27	Shemen	67	5	5	24	206	24	15	36	288	34	35	46
28	Yambol	111	5	6	22	116	13	12	23	120	19	27	32
	Total:	5626	232	270	925	9410	579	602	1237	9695	1080	1433	1968

Source: National statistical institute; Ministry of education and science

Figure 2. Mapscheme of the number of children with dyslexia by districts in Bulgaria, 2022
Source: National statistical institute; Ministry of education and science

CONCLUSION

Dyslexia accompanies people throughout their lives. The problems with difficulties with dyslexia among children and young people in Bulgaria are serious, but the population does not pay attention, is not familiar with and is not interested in the raised issue. A large number of these children are thought to have no interest in learning and education, but in fact, they have a communication disorder. Some children with dyslexia also have attention deficit hyperactivity disorder.

One of the goals of the article - to give more publicity to the problem - has been fulfilled. Parents and specialists in childcare facilities and schools must monitor and recognize the problem in time. That way, the individual work with the child will start as early as possible. There are tests for detecting early markers of dyslexia - a picture test for phonological awareness for children 4-7 years old [9] in Bulgaria. The problem is how many dyslexic children can be tested with it because specialists familiar with the test are not many.

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THE CHALLENGE OF ASSESSING THE SPATIAL TRANSFORMATION CAUSED BY MINING IN B&H – GIS AS A SOLUTION?

DOI: https://doi.org/10.18509/GBP23071s
UDC: 314.114:622.2]:[528.8:004.6(497.6)

Luka Sabljić
Dragica Delić
Faculty of Natural Sciences and Mathematics, University of Banja Luka, Republic of Srpska, **Bosnia and Herzegovina**

ABSTRACT

Bosnia and Herzegovina (B&H) has a long tradition of mining. Until modern times, mining became the backbone of the overall economy of the entire society. However, the spatiality of mining and the effects of the processes that accompany it are not known to the general public. The paper deals with the identification of spatial-temporal changes caused by mining on the example of a surface coal mine in the northeast of B&H. The process of ore exploitation in the first place requires space and usurps land, which represents the economic basis for the inhabitants of rural areas. Therefore, the authors focused on monitoring changes in land cover. The methodology of monitoring land cover changes is based on the use and processing of Corine Land Cover data using QGIS software. The change in the demographic size of settlements affected by mining activities was analyzed using official demographic statistics. The results of the study reveal the dynamics of mining activity, the spatial scale of exploitation over time, and changes in land use in the area of the case study. The research is useful for spatial planning after the exploitation of the ore, but also for the creation of various development policies for the population. This type of study opens up space for monitoring other changes that occurred during exploitation, both in the area of this and other surface mines.

Keywords: mining, spatial-temporal transformation, GIS assessment, Bosnia and Herzegovina

INTRODUCTION

The beginning of the extraction of ore and mineral resources is linked to the distant past. From the first excavations until today, the process of mining exploitation has been modernized and is gaining in scope and intensity. In many countries, the extraction of ores and minerals, along with other activities of the secondary sector, represent the main support for the development of the economy. However, the development of digital tools for monitoring spatial-temporal processes happened later. Considering the complexity and multidimensional character, extraction processes are difficult to monitor and analyze temporally and spatially, and to determine their spatial effects, as well as the direction and extent of the spatial transformations they cause. With the development of digital tracking tools, that process is somewhat easier. As expected, countries with advanced technology were the first to create and implement digital tools and platforms for monitoring transformations in Geospace. In particular, the use of Geographic Information Systems (GIS) in combination with different spatial data is represented for the purpose of monitoring the range of disturbance of the vegetation cover due to mining [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], as well as in the management of land cover after the closure of the mine [11], [12], [13]. The use of GIS for the analysis of mining activities has been present for more than a decade in B&H and in the region [14], [15], [16], [17], [18], [19]. The methodology applied in this paper also appears in earlier studies dealing with mining worldwide [20], [21]. We emphasize that the use of such methodologies for the purpose of monitoring spatial-temporal transformations in mining regions has not been applied to examples from B&H, although there are papers with a similar methodology for the purposes of analyzing other spatial resources [22], [23], [24]. An example of a coal basin in B&H, which will be the subject of this paper, is the area of the municipality of Ugljevik, which belongs to the coal-bearing basin of northeastern Majevica. Coal mining in the area of this case study has a long tradition and has been going on since 1899. The mining tradition, and the production of electricity based on it, represents the economic basis of the population of this municipality, but also of the B&H. The positive effects of this activity are reflected in the multiplication of jobs and income, also putting this municipality in the group of economically developed ones. However, mining activity is accompanied by negative effects on the land cover. Therefore, the subject of the paper represents the identification of changes in land cover due to mining activity and its effect on settlement system in municipality.

METHODS AND DATA

The input data for the research area are vector data about the border of the municipality of Ugljevik, and the borders of settlements in the study area. For the comparative analysis of changes in the structure of study area land, data from Corine Land Cover – CLC (https://land.copernicus.eu/pan-european/corine-land-cover) 2000 and 2018 were used. Using QGIS software (https://qgis.org/), data on land use structure was extracted to the level of the study area. Categorization of land within the paper was carried out by the method of joining land classes from the official CLC nomenclature, to land categories that appear in the cadastral structure of land use (Tab. 1).

Table 1. Categorization of land use structure

Productive	Agricultural	Cultivable	2.1.1 Non-irrigated arable land; 2.4.2 Complex cultivation patterns; 2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation; 2.2.2 Fruit trees and berry plantations
		Uncultivable	2.3.1 Pastures
	Non-agricultural		3.1.1 Broad-leaved forest
Unproductive		Thermal power plant	1.2.1 Industrial or commercial units
		Mining area	1.3.1 Mineral extraction sites; 1.3.2 Dump sites
		Built-up areas	1.1.2 Discontinuous urban fabric

The basic division within the categorization is based on productive and unproductive land. Productive land includes agricultural and non-agricultural lands (CLC: 3.1.1). Agricultural land is divided into cultivable land (CLC: 2.1.1; 2.4.2; 2.4.3; 2.2.2) and uncultivable land (CLC: 2.3.1). Unproductive lands include the following categories: built-up areas (CLC: 1.1.2), and lands with dominant mining activity (CLC: 1.2.1; 1.3.1; 1.3.2).

The impact of mining activities on the demographic characteristics of the area was analyzed based on the available data in the 1991 and 2013 censuses. The estimate of the number of inhabitants at the settlement level is not available for the post-census period, and for this reason, the reference periods of the analysis of changes in land use structures and changes in demographic characteristics do not coincide.

RESULTS AND DISCUSSION

In the analyzed period, changes were observed in the structure of land use at the municipal level. As expected, given the existence of mining activities for the surface exploitation of coal and thermal power plants for burning coal, increased areas of those land categories are visible (Fig. 1, Tab. 2).

Table 2. Changes in the structure of land use at the level of the municipality of Ugljevik in the period 2008-2018

	Productive			Unproductive		
	Agricultural					
	Cultivable	Uncultivable	Non-agricultural	Thermal power plant	Mining area	Built-up areas
Area (ha) 2000	10396.53	115.09	5568.32	59.47	581.84	321.38
Area (ha) 2018	9774.48	114.24	6004.12	78.28	813.93	257.59
Absolute change 2018/2000	-622.05	-0.85	435.80	18.80	232.09	-63.79
Index of change 2018/2000	94.02	99.26	107.83	131.62	139.89	80.15
Share in the total land area in 2000	61.00%	0.68%	32.67%	0.35%	3.41%	1.89%
Share in the total land area in 2018	57.35%	0.67%	35.23%	0.46%	4.78%	1.51%

The increase of surface area in favor of land under mining activities caused changes in other land use categories. The results of the analysis indicate changes in the area of productive land through the reduction of the area of agricultural land in both subcategories: the area of cultivable land decreased by -622.05 ha, and the area of uncultivable land by -0.85 ha. The increase in the area of non-agricultural land (forest) by 435.80 ha can be interpreted as an increase in recultivated areas that were used for mining in the past. The area of unproductive land in the observed period increased in the categories of land used for mining activities. The space for the thermal power plant infrastructure expanded by 18.80 ha, while the mining area expanded by 232.09 ha. The data indicate a decrease in the area under the built-up areas category, but subsequent validation of the data established that there was no change in that category of land use. Those surfaces are not located near the area of mining activities, and are not the subject of a detailed analysis. The change in the share of mining land in the total is positive, but at the municipal level, that share is still small (about 5 %).

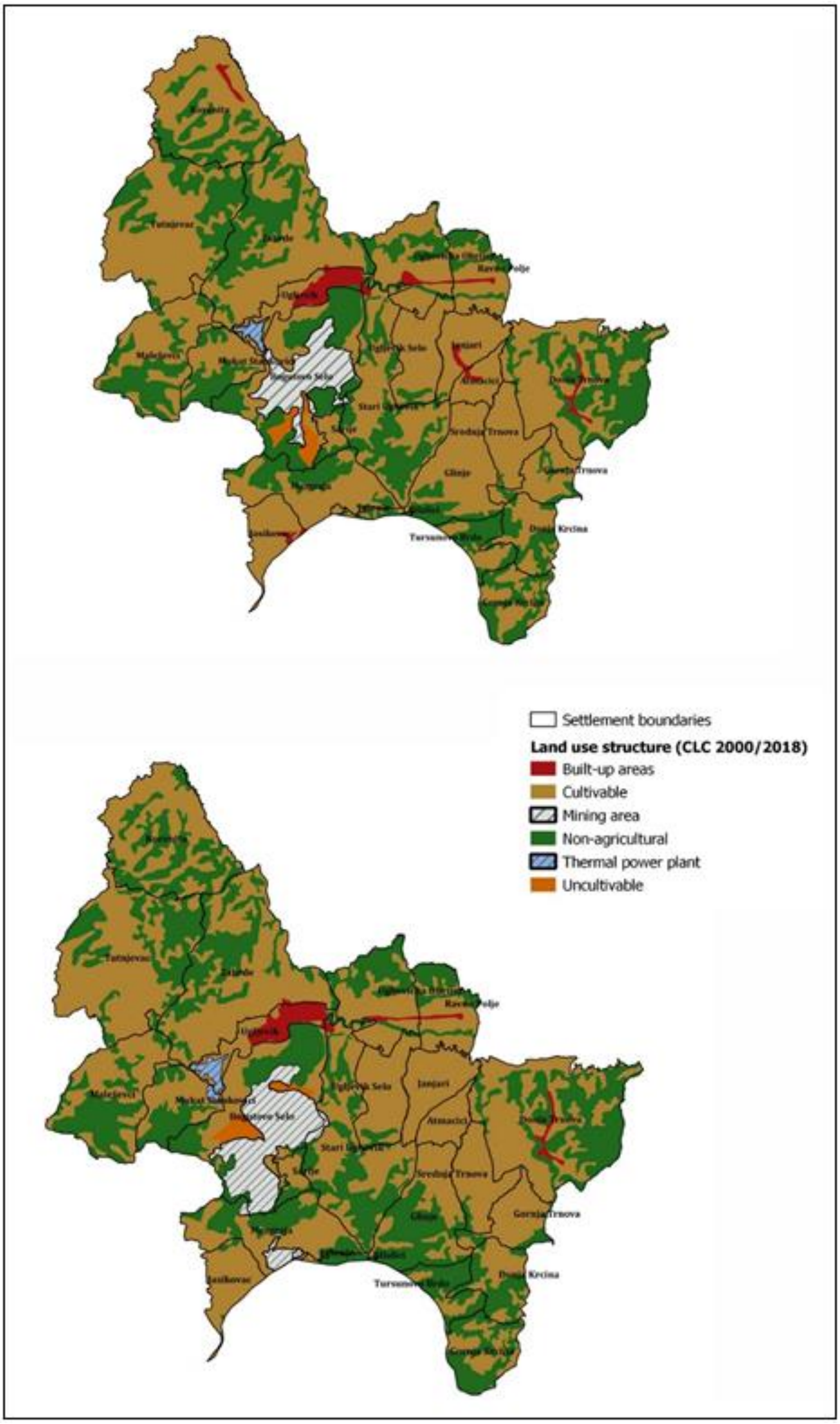

Figure 1. Change in land use structure at the level of the municipality of Ugljevik (CLC 2000 –up; CLC 2018 –down)

Changes in the structure of land use were also analyzed at the level of the settlement system, in order to identify settlements whose land has been usurped by mining activities, as well as the intensity of these changes. The settlements where the land is used for mining activities has been identified: Stari Ugljevik, Ugljevik, Bogutovo Selo, Jasikovac, Mezgraja, Mukat Stankovići (Fig. 1) and they make up 24 % of the settlements in the total settlements network, and occupy 28.22 % of the total territory of the municipality. For a simpler presentation, the results of the analysis are given in summary for all 6 settlements (Tab. 3).

Table 3. Changes in the structure of land use in settlements where mining activities take place

	Productive			Unproductive		
	Agricultural					
	Cultivable	Uncultivable	Non-agricultural	Thermal power plant	Mining area	Built-up areas
Area (ha) 2000	2268.48	114.88	1610.02	59.13	581.79	175.71
Area (ha) 2018	2151.92	114.24	1476.24	77.93	813.72	175.95
Absolute change 2018/2000	-116.55	-0.64	-133.78	18.80	231.93	0.25
Index of change 2018/2000	94.86	99.44	91.69	131.80	139.86	100.14
Share in the total land area in 2000	47.16%	2.39%	33.47%	1.23%	12.10%	3.65%
Share in the total land area in 2018	44.74%	2.38%	30.69%	1.62%	16.92%	3.66%

As expected, the areas of mining categories of land increased in the period under review (by 250.73 ha in total), while the areas of other categories decreased. The area of productive land was reduced by a total of -250.98 ha, and this difference represents the conversion of land for mining activities needs. The share of productive land in the total area of settlements covered by mining activities decreased in the observed period by -5.22 % (from 83.02 % to 77.80 %), while the share of mining land increased by 5.21 % and makes 18.54 % of the area of the observed settlements. A detailed analysis at the level of each settlement, separately, indicates the direction of mining activities. The largest increase in mining areas is noticeable in the settlement of Bogutovo Selo, where this category of land increased by 142.96 ha. Smaller increases occurred in the settlements of Mezgraja (by 64.00 ha), Stari Ugljevik (by 18.14 ha) and Jasikovac (by 6.80 ha). In the settlements of Mezgraja and Jasikovac, coal exploitation begins in the observed period, which was not visible at the beginning of the period. The increase in the area under the thermal power plant infrastructure occurred in the settlements: Mukat Stankovići (by 14.98 ha), Ugljevik (by 3.82 ha) and Bogutovo Selo (by 0.001 ha), and this category of land was present even before the observed period in the mentioned settlements. Looking integrally at the land categories used for mining activities (mining area and thermal power plant), they occupy the most space in the settlement of Bogutovo Selo (45.43 %) and the settlement of Ugljevik, where the thermal power plant is located (15.61 %), while in other settlements occupy less than 10 % of the area.

The conversion of land for mining activities had different effects on the structure of land use in certain settlements. In the settlement of Bogutovo Selo, the area of non-agricultural land (forest) was reduced, while in other settlements, agricultural (cultivable) land was reduced to varying degrees. Mining activities, although small in area, due to their nature have effects on a wider area: changes in the morphophysiology of the relief, changes in infrastructure, changes in microlime and environmental pollution. The local population, which is the driver of economic development, is directly exposed to the above-mentioned effects. Therefore, it is important to assess the demographic characteristics of the area usurped by mining activities. Changes in the demographic size of identified settlements where mining activities take place are shown in Table 4.

Table 4. Changes in the demographic size of settlements where mining activities take place

	Settlement	Total population 1991	Total population 2013	Absolute change 2013/1991	Index of change 2013/1991	Share in the total population in 1991	Share in the total population in 2013
Area of mining activities until 2018	Bogutovo Selo	499	294	-205	58.92	1.95%	1.94%
	Jasikovac	1118	96	-1022	8.59	4.37%	0.64%
	Mezgraja	714	459	-255	64.29	2.79%	3.04%
	Ugljevik	2981	3922	941	131.57	11.65%	25.94%
	Mukat Stankovići	458	330	-128	72.05	1.79%	2.18%
	Stari Ugljevik	1126	707	-419	62.79	4.40%	4.68%
	Total	6896	5808	-1088	84.22	26.95%	38.42%

The demographic size of settlements where mining activities take place decreased in the intercensal period (1991–2013). The settlement of Ugljevik increased its demographic size because it is the only urban settlement in the municipality. In the settlements of Bogutovo Selo and Stari Ugljevik, mining activities were present even before the observed period, while in the other settlements they started after 2000. Therefore, in those settlements, the number of inhabitants can be expected to decline in the process of the expansion of mining and the emigration of the local population. In 1991, the population of settlements where mining activity is currently taking place was 26.95 % of the then population. Today, although they are demographically reduced, these settlements comprise 38.42 % of the municipality's population, which indicates the number of the population that faces the effects of mining activities.

CONCLUSION

In the paper, the CLC digital database of spatial data was used for the analysis of changes in land use. The CLC is an important digital database for monitoring changes in land use because it provides a standardized and consistent classification of land types over 20 years.

The research identified the spatio-temporal dimension of mining activities in the selected research area. Areas under mining activities had a different effect on the reduction of other categories of land use in certain settlements. A regularity was observed: reduced agricultural (cultivable) land in all settlements, with the exception of the settlement Bogutovo Selo, where was a decrease in non-agricultural land (forest). The results indicate the intensity of mining activities, which is the highest in Bogutovo Selo, where was a mine even before the observed period. The expansion of mining activities in the new settlements, Jasikovac and Mezgraja, has been observed. The population living in settlements where mining activity takes place makes up more than a third of the total population of the municipality. The identified population is directly faced with changes in the land use (and therefore sources of income) and potential emigration due to land expropriation.

Namely, mining activities represent activities that take place rapidly in space with dynamic intensity and changing direction of movement. But new CLC data is available

every 6 years, and this is precisely one of the shortcomings of the CLC database in terms of researching mining activities in space. If the analyst wants to track the causes and consequences of mining activities in space for a period of time that is shorter than 5 years, it will not be possible with the CLC database. An alternative solution is the use of satellite images and their classification for the defined time period. The authors of the paper believe that the results of the analysis could be of higher quality and more credible if changes in space (with an emphasis on mining activities) were followed by comparative use of the CLC database and user-classified satellite images.
Certainly, this type of research has a contribution in identifying the spatiality of mining activities in the network of settlements and determining the future effects of mining on the land fund in the network of settlements. The results obtained from this kind of research provide the basis for the creation of government policies regarding the strategic management of human capital and the land fund in the identified settlements.

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THE PRESPA AGREEMENT: A POLITICAL GEOGRAPHY

DOI: https://doi.org/10.18509/GBP23079k
UDC: 341.241(497.773):341.244(497.7:495)
911.3:32

Goran Kitevski
Institute of Geography, Faculty of Natural Sciences and Mathematics, University "Ss. Cyril and Methodius" in Skopje, **North Macedonia**

ABSTRACT

The subject of the research is the Prespa Agreement, which gave North Macedonia a new name, in exchange for support from Greece in North Macedonia's aspirations towards the European Union and NATO. The paper analyzes the key points from the first part of the agreement, which are the essence of the Macedonian-Greek naming issue: the formulation of the Macedonian nationality, the recognition of the Macedonian language, the differences in understanding and the possibility of using the terms Macedonia and Macedonian for the both sides, as well as the meaning of the agreement in a broader political sense. There are a number of researches on the topic of Macedonian-Greek issue, which are more focused on the naming problem, from the occurrence to its solution, so the main goal of this paper is to try to give another, political-geographic overview of the identity issues arising after the Prespa Agreement.

Keywords: Identity, naming issue, nationality, Macedonian, Prespa agreement

INTRODUCTION

The long-standing Macedonian-Greek naming dispute was finally solved with an agreement that also has a long name: Final Agreement for the settlement of the differences as described in the United Nations Security Council resolutions 817 (1993) and 845 (1993), the termination of the Interim Accord of 1995, and the establishment of a strategic partnership between the Parties [14]. Simply known as The Prespa Agreement, signed on 17 June 2018 on the banks of Prespa Lake, is a bilatertal agreement with mutual relations, frontiers, dispute settlement and cooperations as a subject terms [18]. The agreement regulates the Macedonian name issue, which according to Nimetz, is one of the more unusual international confrontations [12], although geographical naming disputes are not uncommon between and within states [8].
The agreement consists of three parts: the first part, entitled Settlement of the difference on the name, the pending issues related to it and entrenchment of good neighbourly relations, with a total of 8 articles; part 2, under the title Intensification and enrichment of cooperation between the two parties, which deals with Diplomatic relations, Cooperation in the context of International and regional organizations and fora, Political and societal cooperation, Economic cooperation, Cooperation on the fields of education, science, culture, research, technology, Health and sports, Police and civil protection cooperation, Defence cooperation, Treaty relations; and part 3: Settlement of disputes, which contains 3 articles. According to Article 20, the Agreement was signed by the Ministers of Foreign Affairs from both Parties, and was witnessed by Matthew Nimetz, the personal Envoy of the Secretary General of the United Nations, in accordance with the Security Council resolutions 817 (1993) and 845 (1993) [14].

The agreement entered into force on February 12, 2019, after both North Macedonia and Greece ratified the agreement in their respective parliaments. The Macedonian part in particular was quite turbulent. In September 2018, North Macedonia held a consultative referendum, in which Macedonian citizens were asked "Are you in favor of European Union and NATO membership by accepting the agreement between the Republic of Macedonia and the Republic of Greece?" The majority of the voters who turned out voted "yes", but the total number of turnouts was far below the legal threshold, so the referendum almost destroyed the entire Prespa process. The issue then was transferred to the Macedonian parliament where, after a series of political turbulences, the agreement was supported and voted by 2/3 of the members of the Assembly, so the constitutional amendments were implemented.

The paper mainly focuses on the first part of the agreement, which contains the points that at the same time are a solution and a problem that emerges from the solution. The name change and the construction of the name North Macedonia and its effect on the identity essence of the Macedonian question is highlighted, but also the other articles of the first part of the agreement that have a certain control function - the resolution of the status of the Macedonian language, the formulation of the nationality in North Macedonia, the differences and similarities in the understanding of the term Macedonia and Macedonian, as well as the possible problems that will arise from the agreement itself in the time being.

THE CHANGE: NOMEN EST OMEN

The Prespa agreement represents the end of the Macedonian-Greek problem regarding the right to use the name Macedonia, but also the beginning of the identity issues arising from the problem and its solution. With the Agreement, the Republic of Macedonia changed its name to the Republic of North Macedonia, somewhat a compromise solution, considering the maximalist policy of Greece from the beginning of the 90s and the opposition to the term Macedonia being included in the name of the newly formed independent country. The abandonment of that maximalist position is a result of different dynamics of the dispute itself, filled with different positions and problems on both sides, until the political alignment in 2017, when both Greece and North Macedonia were ruled by left-wing political structures, willing to take effort to solve the problem. The essence of the problem itself is not only the name of the state, but the right to use the ancient brand Macedonia and everything that that term reflects. Such is the Prespa agreement, which contains not only the solution for the name change, but also the regulation of things to come after the change, because "identity is at the core of the Macedonian name dispute" [11]. According to Article 1.3a, the constitutional name for the second party that will be used erga omnes is the Republic of North Macedonia, and the short version is North Macedonia [14]. North in North Macedonia is a noun, not an adjective, which means that it is an integral part of the name of the country, not a reference. Therefore, the only abbreviated/shortened name of the country is North Macedonia; under no circumstances can it be N. Macedonia, or any other creative way to avoid the composite name, because both North and Macedonia in the name North Macedonia are equal parts. In addition, North Macedonia is the only independent and sovereign country in the world that has the noun "North", because although it is almost non-existent as common knowledge, the name of North Korea is Democratic People's Republic of Korea, nor, in other example, can the essence of the North-South problem be compared with Sudan and South Sudan, because Greece is not called Macedonia [8]. All this is contrary to the folklore narrative present mainly among the apologists of the Prespa Agreement in North Macedonia, where it is said that "North in the name is just an adjective", and "where there is north, there is also south". That is not true, and the problem is much more complex than that.

BEING MACEDONIAN

The conclusion is that according to the Prespa Agreement, the Macedonian language and nationality are explicitly recognized [5], [7], while Vankovska believes that the Prespa Agreement promotes nationality as a political term (demos), turning North Macedonia into a civic state [20] According to article 1.3b, the nationality of the Second Party shall be Macedonian/citizen of the Republic of North Macedonia, as it will be registered in all travel documents [13]. This is both an elegant and problematic solution at the same time. The reference citizen of the Republic of North Macedonia is set to avoid direct application of the new name to the formulation of the nationality: North Macedonia – North Macedonian, something that would complicate the situation to the greatest extent in terms of the identity issue. In this way, the first party (Greece) accepts the term Macedonian, but only with the clarification that it is a citizen of North Macedonia and not of Greece, which is in direct context with Article 7 of the agreement, i.e. the understanding that the term Macedonia and Macedonian have different historical context, and that a Macedonian who is a citizen of North Macedonia is diametrically different from a Macedonian who lives in Macedonia, the northern part of Greece.

With or without the agreement, the very formulation of the term nationality in the documents issued by North Macedonia is problematic. The term nationality in identity cards and travel documents is actually citizenship, and does not reflect ethnicity. North Macedonia, like the vast majority of countries in the world, does not register the ethnicity of its citizens in travel documents. There is no document (birth certificate, identity card, passport) issued by North Macedonia that proves ethnic identity, but only citizenship, which is referred to as nationality. Even Bosnia and Herzegovina, a country which post-Dayton functions on the basis of the rights of the three constituent peoples (Bosniaks, Serbs, Croats), does not register the national affiliation, but only the citizenship on the state issued documents.

The confusing part of this formulation is not only because of the composition, but also the understanding of the problem among the majority of the Macedonian people. The general public does not know and is not aware that the national identity does not appear in any state issued document. In conditions where the public does not differentiate between nationality and citizenship, the formula Macedonian/citizen of the Republic of North Macedonia was understood and accepted as a direct blow to the national identity of the Macedonians - erasing the Macedonian nation and establishing a rough civil identity in North Macedonia. Such a narrative was further fuelled by several fake news prone social media in the country during a post Prespa bureaucratic procedure period. Namely, in a short period of time when issuing new birth and citizenship certificates, instead of the standard wording of Macedonian citizenship, during the transfer to Macedonian/citizen of the Republic of North Macedonia, according to the needs imposed by the Prespa Agreement, several documents were issued where the citizenship column was filled with slashes (nationality: ////). Such a technical-bureaucratic oversight was enough to strengthen the narrative that "Macedonians have been erased as a nation", although the slashes are in the column for citizenship, and citizenship has the same wording for the other nationalities in North Macedonia also (Albanian, Turkish, Serbian, etc.). In addition, the term Macedonian in the recognized Macedonian language, as well as in the Macedonian nationality, is explained through the following article (1, 3d) The terms "Macedonia" and "Macedonian" have the meaning given under Article 7 of this Agreement, Where Article 7 says that both Greece and North Macedonia recognize that the terms Macedonia and Macedonian have a different historical context and historical legacy (7.1.). When the term is used by Greece, it means the northern part of Greece and the people living in that region, their attributes and the whole continuity from the Hellenic civilization to the present day. Accordingly, Greece receives the entire right to use the brand Macedonia, which has continuity from ancient times to the present day – the essence of the Macedonian-Greek problem.

When the term is used by North Macedonia, the terms denote its territory, language, people and their attributes, with their own history, culture, and heritage, distinctly different from those referred to under Article 7(2). First, North Macedonia cannot use the term Macedonia without further specifying, in this case the part of the name, North Macedonia. Similarly, but a little more flexible is the term Macedonian: even in terms of the language, there must be an explanation that the language is from the South Slavic language group, which means that the Macedonian language has nothing to do with the Macedonian language from the ancient era, about we know almost nothing [9].

Secondly, North Macedonia as a country cannot use the term Macedonian in every form and situation. Article 1.3f reflects that problem: The adjectival reference to the State, its official organs, and other public entities shall be in line with the official name of the Second Party or its short name, that is, "of the Republic of North Macedonia" or "of North Macedonia". Other adjectival usages, including those referring to private entities and actors, that are not related to the State and public entities, are not established by law and do not enjoy financial support from the State for activities abroad, may be in line with Article 7(3) and (4), that is, the understanding of the different geographical and historical context of the term Macedonian and what it represents [13]. This is somewhat in line with the civic context that Vankovska writes about, because with the wording where there is no Macedonian prefix, it is avoided to assign a national identity to the institutions that come from North Macedonia. But on the other hand, and more in line with the Prespa Agreement and the intention of Greece, the explicit use of the term Macedonian must be avoided. Nimetz explains this as an awkward formulation which solved a problem [12]. And the solved problem consists in finding a way to avoid the term North Macedonian, nor to use the plain term Macedonian, when, for example, talking about the prime minister of North Macedonia. According to the Agreement, he is Prime Minister of North Macedonia; he is not Macedonian, nor North Macedonian Prime Minister. Nimitz clarifies that this "usage applies solely to official usage; what people use in unofficial contexts is a matter of ordinary use of language". It is the ordinary use of language that is the problematic part regarding the possibility of developing the term North Macedonian instead of plain Macedonian. For example, in ordinary use of the Macedonian language, the Prime minister of South Korea, is South Korean Prime minister (Juznokorejskiot premier), or Brendan Rodgers is Northern Irish football manager (Severnoirec). That means than even in the Macedonian ordinary use of language, the term North Macedonian is common.

The Government of North Macedonia issued Q&A website for the public, as well as guidelines for the media precisely on the correct use of the term Macedonian [15], [17], where it is clarified that anything connected to the state, the government, the presidency, private entities and actors related to the state or activities financed by the state abroad will use the adjective North, but it is not necessary to use it otherwise, for example for food

[15]. According to Braun et al., the modifier, e.g. for describing the origin of things, is not affected by the change either, so that cheese from North Macedonia remains Macedonian cheese, whereas neither "North Macedonians" nor "North Macedonian cheese" exist [4]. Similar to that argument, on the website of the Government it is emphasized that one can also talk about Macedonian culture, Macedonian history, Macedonian literature, the Macedonian Cyrillic alphabet, Macedonian churches, Macedonian ethnic identity and so on, but also that it should be taken into account that Macedonia and Macedonians mean something distinctly different in Greece [15]. Meaning that when there is another type of Macedonia and Macedonians that are distinctly different, then at any cost there must be an additional explanation of which type we are talking about.

The main question is whether the term Macedonian can be used when talking about Macedonians from North Macedonia in an ethnic sense. Since the agreement does not address this directly, and Article 1.3b is intended for Macedonian nationality (citizenship) and it does not cover only ethnic Macedonians, but all citizens of North Macedonia regardless of their ethnicity, then it is a matter of what Nimetz emphasizes as ordinary use of language. First, according to the agreement, there are two basic types of Macedonians, while from the problems in understanding the agreement itself, there are additional subtypes of Macedonians. As defined in article 7, point 3 and the different understanding of the term Macedonian, in the northern part of Greece, live Macedonians who are direct heirs of the glorious Hellenic civilization. In North Macedonia, on the other hand, live Macedonians who have their own specific history and characteristics, completely different from the Macedonians from the northern part of Greece. But they are both Macedonians. Not only that to claim to have a 'culture, and heritage, distinctly different' from those of one's neighbour’s is as futile on historical grounds as it is fundamental for any national conception of history [16], but this formulation further complicates the situation in understanding and solving the problem. Although Greece does not recognize any nationality other than Greek, and no matter how it is regulated and perceived, in Macedonia, i.e. the northern part of Greece, among other, live Slavic speakers, who identify themselves as Macedonians, who according to the agreement they are Macedonians, direct heirs of the Hellenic civilization, although according to their attributes they are much more similar to the second type of Macedonians, i.e. the Macedonians who live in North Macedonia, and who, according to the agreement, have a totally different characteristic from those Macedonians who are of ancient continuity.

The Prespa process and the whole understanding of the problem creates another, political inner Macedonian problem, that Ognen Vangelov calls a possibility of a creation of a bifurcated ethno-nation with an intractable cleavage (two sorts of Macedonians within Macedonia) which would create a protracted instability [19]. In short, in the second type of Macedonians (from North Macedonia) there is one type of Macedonians who are in line with the narrative of the Prespa Agreement and the South Slavic genesis, and the other type of Macedonians, strict opponents of the agreement itself who consider that one of the biggest problems of the agreement itself is the loss of the ancient line. This division is somewhat a continuation and confirmation of the polarization of Macedonian society along the lines of those who "defend" the Macedonian national identity and those who "harm" it [2].

The two main types of Macedonians that the agreement itself treats have a regional identity (Greek Macedonians) and a national identity (Macedonians from North Macedonia). Considering that Macedonians with a regional identity cannot reflect

"Macedonianism" outside of Greece, the main question is whether Macedonians from North Macedonia will be treated as plain Macedonians, or ordinary use of language will formulate the demonym North Macedonian, analogous to the new name of the state, and to differ the Macedonians from North Macedonia from the Macedonians from Macedonia (Greece).

In some sense of what Pergantis [13] points out that the limitations of the law of treaties and the consensual construction of inter-State relations, as well as the ambivalent language of the Agreement regarding North Macedonia's obligation to promote the name solution, lead to the conclusion that the Agreement cannot produce effects on third parties, especially on whether others will address the people living in North Macedonia with Macedonian or North Macedonians. Or similar to what Kofos [10] emphasizes about the name of the state before the Prespa Agreement, where third parties who neither understand the problem nor want to have anything to do with it, developed the possibility for the state to be called Republic Macedonia, or just plain Macedonia. Thus, post Prespa, it depends on the will and the ordinary use of language of third parties whether the exonym for Macedonians will have a reference like the name of the state or not.

BETWEEN THE HAMMER AND THE ANVIL

North Macedonia began its European and Atlantic path in the mid-1990s, being the first post-Yugoslav state to sign the Membership Action Plan (MAP) with the Alliance (1999) and the Stabilization and Association Agreement (SAA) with the European Union (2001) [3]. All political parties in North Macedonia have EU and NATO membership as a strategic goal in their platforms [18]; therefore, there can be no discussion of any alternative geopolitical orientation of North Macedonia instead of EU and NATO membership, although one can argue that popular support for EU and especially NATO is far lesser than the numbers operated, which are probably a replica of the corresponding party conviction.

Greece managed to tie North Macedonia's aspirations for membership in the European Union and NATO to the naming issue, so the entire "Prespa process", including the referendum, was linked to EU & NATO in a way of compensation. Such was the rhetoric in the positive campaign of the domestic political protagonists, as well as of the high foreign statesmen who spoke about the future of North Macedonia, although membership in the European Union was never explicitly promised and guarantied. After the entry into force of the Prespa agreement, North Macedonia was introduced as the 30th member of the NATO pact, while the European path did not get the expected accelerated dynamics.

North Macedonia did not start accession negotiations in 2019, as President Macron felt that the enlargement process needed to be restructured before negotiations could open [6]; nor in 2020, when North Macedonia was blocked again, this time by Bulgaria, supposedly for not fulfilling the previously agreed. Currently, the European path of North Macedonia is laid out by solving the problem with Bulgaria, which essentially covers the identity lines of North Macedonia, with whom Greece had no problem.

The Prespa agreement takes on a different dimension whenever a new obstacle appears on the European path of North Macedonia, as in the case of the problem imposed by Bulgaria. But when North Macedonia once accepted the painful compromise for the greater good (EU and NATO), then it is understood that there is no other way, but all the way, which further complicates the negotiating position of North Macedonia.

The Prespa Agreement has another great meaning in regional political geography. Many analysts have quickly tried to draw parallels or lessons learned from the Prespa

Agreement for a potential Kosovo-Serbia deal [1], and they have a point. At the very beginning, the agreement was seen as a model for compromise, peace and tolerance. But with the passage of time, and the futility of the agreement itself in context of the European path of North Macedonia, the question begins to arise whether other countries would decide on a similar solutions, after what happened to North Macedonia after Prespa. On the other hand, after the Russian aggression in Ukraine (2022) and the NATO consolidation and membership aspiration of Finland (fulfilled) and Sweden (pending), North Macedonia's membership in NATO and the guaranteed political stability add a strong and positive light to the painful compromise from Prespa.

CONCLUSION

The essence of the political geography of North Macedonia in a neighboring and regional context lies in constant proving of the similarities and differences with the others, as well as the unequivocal need for convergence in the large European and NATO family. Ever since independence, the country's central geopolitical goal has been the membership in the European Union and NATO, which was largely obstructed by the valuable voice of Greece, which imposed the bilateral problem of the use of the term "Macedonia" at the international level and as a reception element for North Macedonia in the EU and NATO. With the Prespa Agreement, after 27 years of a period filled with different dynamics, North Macedonia and Greece agreed to put on paper how much they differ and to emphasize to the world how much those differences mean and how they should be implemented. The name change from the Republic of Macedonia to North Macedonia with erga omnes status represents the tip of the iceberg of the entire naming issue process. The possibility of the different understanding and use of the terms Macedonia and Macedonian is the main subject of the content of the agreement, but also the very reason for the agreement itself. It is regulated that both Greece and North Macedonia, when it comes to the term Macedonia and Macedonian, mean two different things, of which Greece retains the right to the Macedonia brand, while North Macedonia may not use the term Macedonia without the noun North in front. The same is true for the term Macedonian - although the agreement acknowledges the Macedonian language when talking about the language spoken by the majority of the citizens of North Macedonia, there is still a certain reference in that direction, i.e. an explanation that that language is a South Slavic language, which separates it from the ancient Macedonian language. Official authorities from North Macedonia cannot use the term Macedonian, but rather the wording "of North Macedonia" – awkward formula just to avoid the term North Macedonian, which would come naturally as an explanation of which type of Macedonian we are talking about. Similar, practical but awkward is the formulation of nationality, that is, the status of citizenship for Macedonian citizens. Post Prespa, the nationality is Macedonian/citizen of North Macedonia, which is another proof that North Macedonia cannot use the term Macedonian without an explanation. In order to avoid the resulting North Macedonian in terms of citizenship, the solution was reached with an explanation, that the Macedonian is from North Macedonia. A certain time is needed to see if the ethnonym for the Macedonians will be plain Macedonian, or ordinary use of language will form the term North Macedonian, given that the Prespa Agreement does not explicitly regulate that issue, nor a third party is obligated to understand that problem; as well as the fact that shortly after the implementation of the agreement, there are already indications for both variants. On the other hand, it is problematic to use the terms Macedonia and Macedonian for Greece as well, given that Macedonia is a regional entity

within the country itself, while the term Macedonian is assigned and refers to people living in the northern region of the country, that identify themselves with the regional Macedonian identity, which cannot have an external identification (exonym).
One of the functions of the agreement was the opening of the open doors of the EU and NATO for the long-time aspirant North Macedonia. In 2020, North Macedonia promoted itself as the 30th member of the NATO alliance, but at the same time received a new obstacle on the way to the EU, this time in the problem of similarities with Bulgaria. So, the Prespa Agreement regulates the difference on many levels between the two neighbors, North Macedonia and Greece, while it stands as a factor in solving the problems of similarities between the two neighbors, North Macedonia and Bulgaria. The Prespa Agreement after its signing was considered a key event in political geography, and an example of solving complicated political problems, but over time, such status of the agreement is under threat of fading, with the increase of Euroscepticism in North Macedonia and the region also, especially in conditions when North Macedonia decided on a painful compromise without getting the main goal (European Union) in return.

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THE PROCESS OF POPULATION AGING AS A DETERMINANT OF THE ECONOMIC DEVELOPMENT IN THE REPUBLIC OF NORTH MACEDONIA

DOI: https://doi.org/10.18509/GBP23089at
UDC: 911.3:314.116-043.92]:330.34(497.7)

Biljana Apostolovska Toshevska
Marija Ljakoska
Mirjanka Madjevikj
Hristina Ninevska
University of "Ss Cyril and Methodius" - Skopje, Faculty of Natural Sciences and Mathematics, Institute of Geography, Skopje, **Republic of North Macedonia**

ABSTRACT
The image of North Macedonia as a country with a young population has faded over time, especially in recent years. The official population statistics data show that the process of population aging in the country is nearly the same as that of highly developed countries.
The working-age population is the most affected, and therefore, this paper focuses on analyzing this age group from 2002 to 2021. The population age structure and population aging are used to define the extent and features of the working-age population in the country, but also at a regional level in order to highlight the differences that exist because the working-age population also serves as the basis for future economic development and sustainability, investments, regional planning, and development, etc.
The research in this paper is focused on identifying the future direction of development as well as the serious changes taking place in the working-age population through the obtained results. Also, the aim is to formulate activities and policies to mitigate the effects of demographic aging and to contribute to defining guidelines and creating population, social and economic policies for the country at a national, regional, and local level.

Key words: population aging, working-age population, determinant, economic development, North Macedonia

INTRODUCTION

Population aging is a global phenomenon in the 21st century, characterized by a delay in births, a drop in fertility rates, the impact of living conditions and standards, as well as the volume and dynamics of migration. According to current demographic events and processes, projections for 2050 show that persons aged 65 years and more, will make up 16.2% of the global population, and even 25.7% of the population in developed countries [60]. By the mid-century, one in six people globally will be aged 65 years or older. The number of people older than 60 years has surpassed the number of children since 1995, and it can be expected that by the year 2050, in Europe, there will be twice as many old people as children (UN, World Population Prospects 2019)[1]. Also, the latest projections

[1]https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/files/documents/2020/Sep/un_pop_2020_pf_ageing_10_key_messages.pdf

suggest that there will be 13.5 % fewer people aged less than 55 years living in the EU-27 by 2050 [22][2].

This raises concerns in countries that are particularly affected by this phenomenon, where the problem is foreseen in the biological renewal, economic development, and expected economic pressures, and as a severe impediment to complete for long-term social development. In particular, "If demographic trends have a significant impact on the fate of nations, one, in particular, deserves special attention due to its far-reaching consequences. It is the population's aging." [18], [52]. With the increase in the average age of the population, many problems will appear, which are not only of a demographic nature, because the changes in economic, social, and political conditions will be visible as well [58], [52].

According to Landry (1909) [32], and Huxley (1960) [28], the roots of population aging are primarily tied to the demographic transition, which is linked to the industrial revolution, the growth of capitalism, and numerous changes in society's overall structure. Namely, in Western and Northern Europe, for example, the transition from traditional to modern reproduction began in the second part of the 18th century and lasted until the 1930s of the last century. Later, the industrialized countries had a delayed transition, but the demographic shift is now complete in all industrialized countries [45], [59].

Although the drop in the birth rate is essential to this phenomenon, in the mid-twentieth century, a decrease in mortality, as well as advances in medicine and better living conditions, contributed to the population aging. "At the same time, birth delays in industrialized countries shifted the upper optimal age of the reproductive population, and because of the shorter reproductive period and lower number of offspring, it frequently decreases the upper limit, even though this group is biologically determined" [20].

The demographic transition took place at a different pace in less developed countries. They faced a greater population natural increase rate and a big share of young individuals; yet, population aging is becoming more visible in these countries as well [50].

Demographic aging and its implications are in different fields and the knowledge is different given the spatial, demographic, and economic specifics. Its almost universal presence has led to it being a key social, economic, health care, and cultural issue with a wide spectrum of impacts [36], [55] .

In the paper by Bloom et al., (2010) [12] it is stated that the effect of aging on economic growth will be ambiguous, as the various behavioral responses may impose economic growth effects of different magnitudes across different countries. Therefore, population aging has more than a simple accounting effect on economic growth.

Declining fertility is a global phenomenon and is closely connected with economic development [63]. It has changed the role of women in family matters and allowed women to become more involved and present in the labor market and has allowed them greater independence [12], [33].

An increase in the number of older people along with a decrease in the birth rate leads to an excessive burden on the economically active part of the population. Such imbalances threaten to reduce the workforce, slow economic growth, increase social spending, increase the fiscal burden [25], inflation [49], all of which could put enormous pressure on the pension and health care systems, and would ultimately hinder the economic growth of those countries [25].

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[2] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments#Older_people_.E2.80.94_population_overview

Although there are differences in the level of demographic aging between EU countries [43], [15], [56], [55], in general, the demographic trends within the European Union and the deterioration of the population age structure, in the long run, point to an increasingly pronounced reduction in the labor force as the main source for the active population (labor force) but also to aging of the active population [46]. In fact, the aging of the population is worryingly defining the scope and age of the working-age population [1], [11], a phenomenon that we will refer to as "workforce aging". "Workforce aging is likely to be a significant drag on European productivity growth over the next few decades. The greatest negative impact will occur in those countries — such as Spain, Italy, Portugal, Greece, and Ireland — where rapid workforce aging is expected, and which also faces high debt burdens." [1]. Only in the period from 1995 to 2017, central, eastern, and southeastern European (CESEE) countries lost about 7% of their workforce, consisting mostly of young and educated workers. The estimates by the United Nations suggest that the population in the region will face a decline of 12% by 2050 as a result of aging and migration. The workforce will fall by a quarter in the same period. As for our neighboring countries, it is expected that Bulgaria by the year 2050, will lose up to 30% of the workforce, and Serbia around 20% [10].

The demographic aging phenomenon is present in all Balkan countries, but the intensity and the stadium of the process differ, depending on numerous factors like cultural, religious, and ethnic heterogeneity, as well as different socio-economic and political processes that occurred during the second half of the 20th and the beginning of the 21st century [31]. Significant information about this phenomenon and its consequences in the region and beyond can be summarized in the papers of Aleksandrova and Velkova (2003) [2]; about the population aging and its consequences in the Balkan countries, (Magdalenić & Galjak, 2016 [40]); about the aging process within the age structural transition in the Balkan countries [16], [27], on aging in Central and Eastern European countries; Jakovljević and Laaser (2015) [29], for 17 countries in transition from SE Europe; the aging trend of the early 21st century in Serbia [48] ; on aging and demographic change in European societies [42] ; on the impact of the aging process of the working-age population in the Republic of Macedonia in the paper of Dimitrieva and Janeska (2001) [21]; the impact of aging on the working-age population in the Republic of Macedonia in the paper of Risteski (2016) [51]; about the demographic components as a basis for forming a working-age population in the Pelagonia region in R. Macedonia, [7], age structure of the population in the East region of the Republic of Macedonia in the aspect of spatial planning [38], etc.

Changes in the aging population cause major changes in the population structures and demographic resource characteristics, which are the foundation for economic development and have a considerable impact on the country's labor force market. Also, population aging will have additional implications on health and social protection, public finances, and pension funds. In this paper, the starting hypothesis is that demographic aging will affect future economic development. The paper attempts to establish a link between population aging and economic development conditions, addressing the elements that produce population aging as well as their impact on the volume, dynamics, and forecast of the working-age population, as well as its median age. In the analyses done for this research, the territorial element of designating old and young zones is studied, an estimate for the working-age contingent is constructed, and four probable scenarios are highlighted.

METHODOLOGY AND DATA SOURCE

Population aging is defined as a process in which the share of people aged 60 and over or 65 and over increases, with the age ratio as the primary indicator [53], although, this phrase refers to a process in which the elderly population becomes more involved compared to the working-age population [9].

In the determination of demographic aging at a national, regional, and municipal level, different indicators were used, like average population age, the share of the population younger than 20, the share of the population younger than 40, the share of people older than 60, as well as the population aging index. The values and the determination of the stadiums of population aging are according to Penev's classification (1995).

Table 1. Stadiums of demographic aging and criteria for their determination (Penev, 1995)

Stages of demographic aging		Average age (year)	Young population (0-19) in %	Young and mature population (0-39) in %	The older population (60+) in %	Index of aging (4/2)
1	Early demographic youth	0-20	58+	85+	0-4	0-0,07
2	Demographic youth	20-25	50-58	75-85	4-7	0,07-0,14
3	Demographic maturity	25-30	40-50	65-75	7-11	0,14-0,28
4	Threshold of demographic old age	30-35	30-40	58-65	11-15	0,28-0,50
5	Demographic aging	35-40	24-30	52-58	15-20	0,50-0,83
6	Deep demographic old age	40-43	20-24	45-52	20-25	0,83-1,25
7	Deepest demographic old age	43+	0-20	0-45	25+	1,25+

In order to analyze the changes that have occurred regarding population aging and labor force aging in the country, several indicators were calculated using mainly data from the State Statistical Office of North Macedonia[3].

Population aging index

Indicator of the ratio of people aged 60 and over and young people up to 19 years. The aging index's limit value is 0.44. It is assumed that the population has begun to grow old when the index exceeds this value [52], [9], [30].

Population aging ratio

The share of people aged 60 and over or 65 and over in the total population. The limit value of the population aging ratio is 12% [52], [9], [30].

Mean or average population age

Average years of life of the population at the time of the census (in our case, the population estimates). It is calculated as a weighted arithmetic mean

$$\bar{x} = \frac{\Sigma_x \times f}{\Sigma_f} \qquad (1)$$

$\bar{x}$ – is the mean or average population age, $\Sigma_x \times f$ – is the total distribution (x = dilute mean of age groups) and f – population frequency [9], [30] .

[3] State Statistical Office [Online] Available at www.stat.gov.mk (last accessed in May 2023).

The median age of the working-age population

The most appropriate measure of central tendency for an age distribution is the median. The median age of an age distribution may be defined as the age that divides the population into two groups of equal size, one of which is younger and the other which is older than the median. It corresponds to the 50-percentile mark in the distribution.

$$M_x = L_1 + \left[\frac{\frac{N}{2} - \Sigma f_1}{f_{Mx}}\right] \times i \qquad (2)$$

M_x – is the median age, L_1 – the lower limit of the medial interval class, $\frac{N}{2}$ is the total population number (the frequency) divided in 2, Σf_1 – the sum of all frequencies in the cumulative sequence ("less than") to the median interval class, f_{Mx} – the frequency of the medial interval class and i – the size of the medial interval class [9], [30], [57].

Inflow in the working-age population

In the total number of the working-age population for the next five-year period, we count the number of people aged 10-14 at the beginning of the period [9].

Outflow from the working-age population

The working-age population for the next five-year period counts the number of persons aged 60 to 64 at the beginning of that five-year period, assuming that everyone will be alive at the end of that period [9].

The growth rate of the working contingent

Using the five years age groups data, the volume of the working contingent of the population can be calculated at the beginning of the five-year period $P_{(15-64)I}$ and at the end of that period period $P_{(15-64)i+4}$

$$P_{(15-64)i+4} - P_{(15-64)i} = \Delta P_{(15-64)} \qquad (3)$$

If the inflow in the contingent of working age population for the next five-year period is deducted from the data on age structure i.e., the population aged 10 to 14 years from the previous five-year period, the outflow from the working contingent is calculated as the difference between the inflow into the working contingent and the growth of that contingent. S_R= E_R- $\Delta P_{(15-64)}$ Furthermore, the growth rate of the working contingent is calculated using the formula [9]:

$$s' = \frac{P_{(15-64)i+4} - P_{(15-64)i}}{P_{(15-64)i}} \times 100 = \frac{\Delta P_{(15-64)}}{P_{(15-64)i}} \times 100 \qquad (4)$$

Substitution coefficient

The ratio between the absolute size of the inflow and the outflow of the working-age population [9].

$$z' = \frac{E_R}{E_R - \Delta P_{(15-64)}} \times 100 = \frac{E_R}{S_R} \times 100 \qquad (5)$$

Crude birth rate

The simplest and most common measure of natality is the crude birthrate. The crude birthrate is defined as the number of births in a year per 1000 midyear population—that is:

$$\frac{B}{P} \times 1000 \qquad (6)$$

where B is the number of births and P is the midyear population [57].

The Total Fertility Rate (TFR)

According to the Population Reference Bureau[4], TFR is defined as the average number of children a woman would have if she survived all of her births or reproductive years. Reproductive years mean the age between 15 and 49 years. If that value is 2.1 it means that a basic population reproduction is ensured, i.e., that there is a replacement of generations. This value is known as the critical value.

Crude death rate

Is the simplest and most common measure of mortality. The crude death rate is defined as the number of deaths in a year per 1000 of the midyear population. That is,

$$\frac{D}{P} \times 1000 \qquad (7)$$

where D is the number of births and P is the midyear population [57].

Crude natural increase rate

The crude rate of natural increase is thus the (algebraic) excess of births over deaths per 1000 of the population, or the difference between the crude birthrate and the crude death rate. This rate can be expressed as

$$\begin{aligned} r_n &= \frac{B-D}{P} \times 1000 \\ &= b - d \qquad (8) \end{aligned}$$

where r_n = rate of natural increase, B = births during a calendar year, D = deaths during a calendar year, P = midyear population, b = the birthrate, and d = the death rate [57].

Crude net migration rate

The difference between moving to a certain area and moving out of the same area, in a certain time interval

$$\frac{I-E}{P} \times 1000 \qquad (9)$$

I is the number of immigrated persons, E is the number of emigrated persons, and P is the midyear population [57].

For the purpose of this research, four scenarios were developed. They are considered a valuable tool that helps organizations to prepare for possible eventualities and makes them more flexible and more innovative [26].

The creation of the scenarios for the effects of population aging in the future demographic development, used in this paper is a result of quantitative and qualitative analysis [3], [14], [65].

During the development of the scenarios, several phases of activities were distinguished throughout the quantitative analysis: gathering and analyzing the available data for demographic movements, and analysis of the previous demographic trend and processes. Tracing the indicators of the labor market and human capital was analyzed the unemployment based upon the Employment Agency of the Republic of Macedonia during the COVID-19 pandemic, and the estimations for replacement of the working-age

[4] https://www.prb.org/glossary/

population. Connecting all demographic changes with the indication to create the scenarios through the cross-sector analysis which determined the position of the young and old population. The quantitative analysis is based on published papers, field research in the period from June 2019 until July 2020, conducted interviews with specific focus groups regarding migrations, and interviews with people that have migrated (during 2020).However, scenarios do not predict the future, but it explores multiple plausible future situations [64], with the purpose of extending the sphere of thinking of the participants in the scenario development process [23], [24], [54], [65]

According to the Law amending the Law on the Territorial Organization of the Local Self-Government adopted in August 2008[5] [34], analyses for the volume, dynamics, and population structures by gender and age are undertaken at the national level, regional level (NUTS 3 - eight planning regions), and municipality level (NUTS 4 - 80 municipalities). The analyses of internal and international migration movements are performed at a national level, regional (NUTS 3), and municipality level (NUTS 4) for the period 2002 – 2021.

DEMOGRAPHIC DETERMINANTS OF POPULATION AGING IN NORTH MACEDONIA

The country's population has gone through all stages of the demographic transition in a very short period of time (between 1930 and 2000), such that the population natural increase has dropped below 5‰ at the turn of the century [19] and in 2002 it was 3.1‰. The rate rapidly decreases at the beginning of the second decade of the 21st century, reaching -5.4‰ in 2021. If in 2002, a negative natural increase rate was recorded only in the Pelagonia region, in the last analyzed year, all regions have a negative natural increase rate, among which the lowest values were recorded in the Skopje (-2.4‰), and Polog regions (with -3.2‰). With a declining rate of -10.1‰ in 2021, the East region has the most unfavorable value.

The Skopje region had the highest birth rate of 12‰ in 2021, which is above the national average (10.2‰.). Within this region, the highest values for the birth rates were recorded in the municipalities Arachinovo (20 ‰), Studenichani (19.7‰), Zelenikovo (18.7‰), Saraj (16.1‰), Centar (16.3‰), and Shuto Orizari (14.8‰). Right after the Skopje region, is the Polog region with 11‰. The birth rate in the East region is the lowest (7.8‰).

As the number of births declines, so does the total fertility rate (TFR). Throughout the studied period, this value has been substantially below the critical value of 2.1 children per woman of reproductive age, needed for generation replacement. The national total fertility rate has dropped from 1.8 in 2002 to 1.6 in 2021. The highest value of TFR was in the Skopje region (1.9), while the North-Eastern and Vardar regions have values of 1.6. All other regions have TFR of 1.4 and 1.5.

[5] Official Gazette of the Republic of Macedonia "No. 49/1996; 59/1996; 55/2004; 98/2008; 101/2008

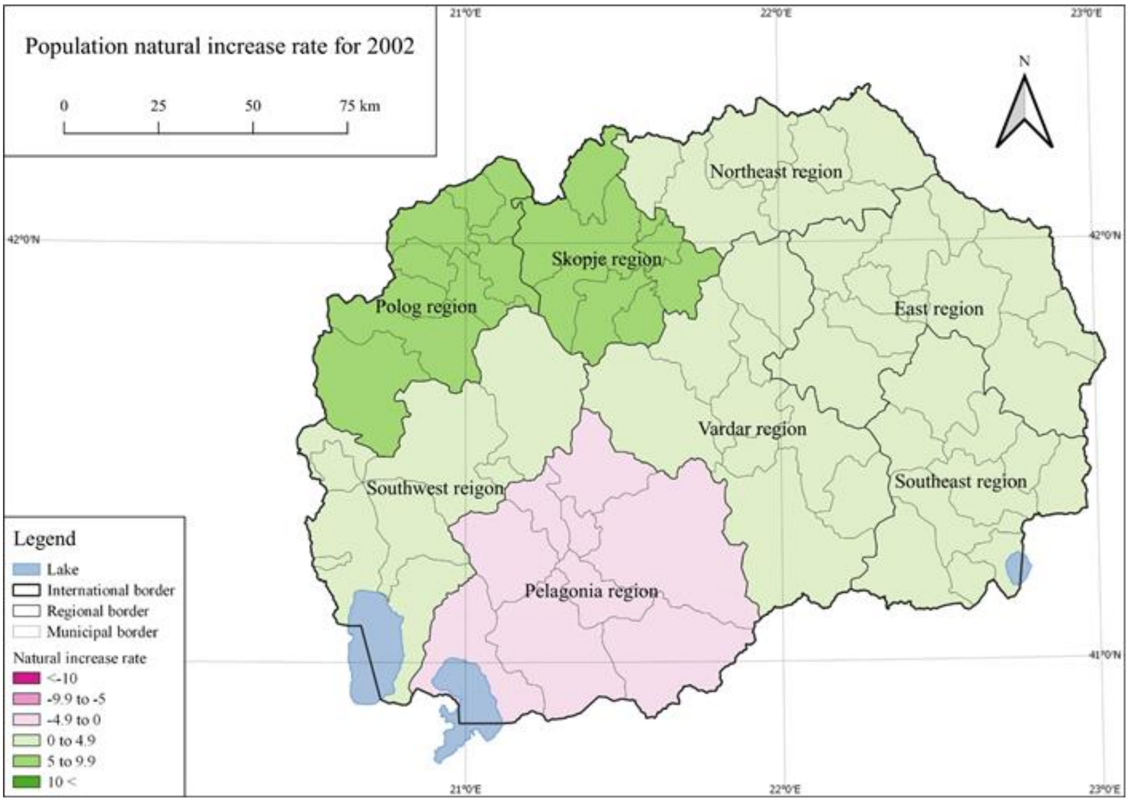

Figure 1. Population increase rate for 2002

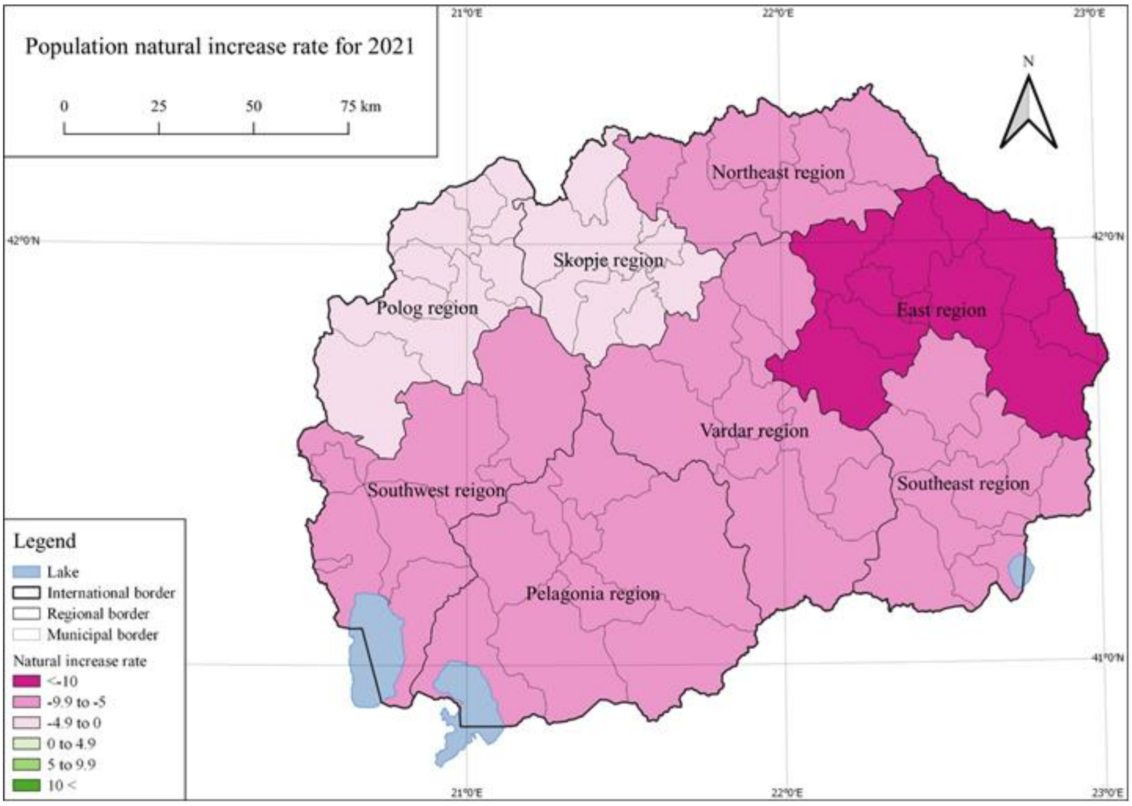

Figure 2. Population increase rate for 2021

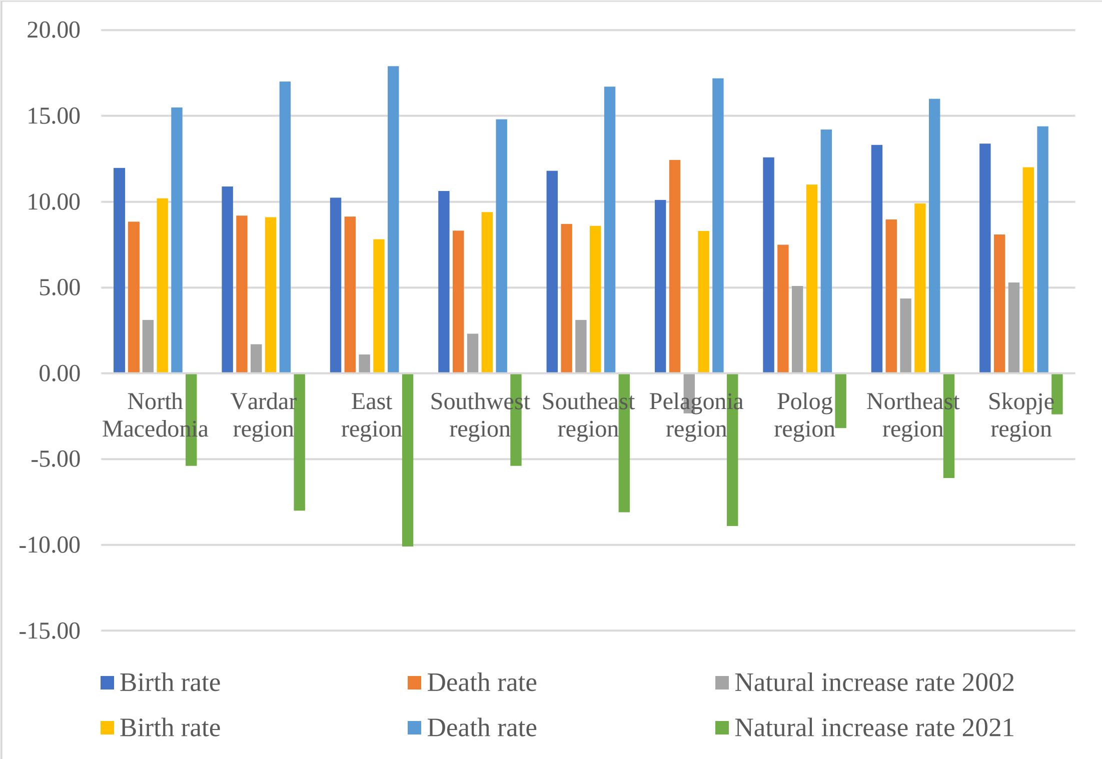

Figure 3. Birth rate, death rate, and natural increase rate for 2002 and 2021, by region

Changes in the number and birth rates occur as a result of changes in society and lifestyles, which lead to an increased share of women in the educational process and the (labor) market, delayed marriage, and giving birth at an older age, which leads to a shorter reproductive period [35]. The acceptance of modern lifestyles and the definition of the role of the genders in society and the family; the right to self-determination for the (non)realization of parenthood, "dramatic shift in norms toward progressiveness and individualism, which moves away from marriage and parenthood" [61] where "altruism is replaced by individualism", in which, "first and foremost, individual rights and self-fulfillment are emphasized ... who make plans for their future based on a mix of familyism, consumerism, careerism, and other lifestyles." [51] … led to the definition of the birth (fertility) rate, which has been steadily declining in recent years.

The mortality rate has increased from 8.84‰ in 2002 to 15.5‰ in 2021. The increase in the mortality rate is present in all regions, which is the result of the rapid process of population aging. In five regions, the values are higher than the national average (Southeast, Vardar, East, Southeast and Pelagonia), while the other three were below the value of 15.5‰. The East region had the greatest mortality rate (17.9‰) in 2021, while the Polog region had the lowest (14.2‰). Out of a total of 80 municipalities, 40 have higher mortality rates than the national average. The highest value was recorded in the municipality of Staro Nagorichani (30‰), followed by Novaci (26.8‰), Novo Selo (26.8‰), Lozovo (26.5‰), and Pehchevo (24.1‰), Cheshinovo (23.8‰), Demir Hisar (23.6‰), Debarca (22‰), Mogila (21.6‰), Zrnovci (20.1‰) and Kratovo (20‰). All of this reflects on the volume and age structure of the working-age population, as well as the population structures, range, and pace of population "feeding" of the young population age group. The process and intensity of population reproduction, as well as the structural linkages developed between the birth rate and mortality, are critical for every country's economic development [9].

The long-term high unemployment rate [8], associated with a significant increase in poverty and social exclusion among several population segments has been considered the most important "push" factor for emigration [44].
Emigration is primarily characteristic for the young population, the core of the working-age population, and the fertile contingent (aged 20 to 39 years), which in the emigration areas cause a reduction in the volume of these age groups, resulting in so-called shortened generations [9], whereas, in the immigration areas, these generation groups mark an extension.
From 2002 to 2021, of the total number of internal migrants, even 75.4% were involved in the migration between municipalities. A total of 63,085 people were involved in migration movements among the eight regions. Thereby, 41.8% of the total migrations were directed to the Skopje region which in the entire analyzed period is the only region with positive net migration in the country. Mainly directed towards the municipalities of Skopje, internal migrations create the basis for a series of problems that can arise due to the unequal distribution of population, and disadvantages in the gender and age structure of the population in particular regions [4], which creates a situation of demographic and economic polarization [37], [5], and on the other hand, there is an intensive demographic emptying and creation of an unfavorable demographic state.
Except for the Skopje region, over 90% of the emigrated population in all other regions is in their working-age with over 70% of the population aged 20 to 39 years old in all but the Skopje region. People aged 30 to 64 are most frequently involved in the overall migration between municipalities, followed by people aged 15 to 29, only with a slightly smaller share. More than two-thirds of the participants emigrating from the rural municipalities are between the ages of 20 and 39, i.e., the working-age and reproductive population, which is critical for the municipalities' demographic and economic survival [39]. The positive net migration in international migrations comes as a result of the immigration of foreign citizens [6]. Starting from 2005 to 2021, with few exceptions, the net migration for the citizens of the Republic of North Macedonia has a negative sign.

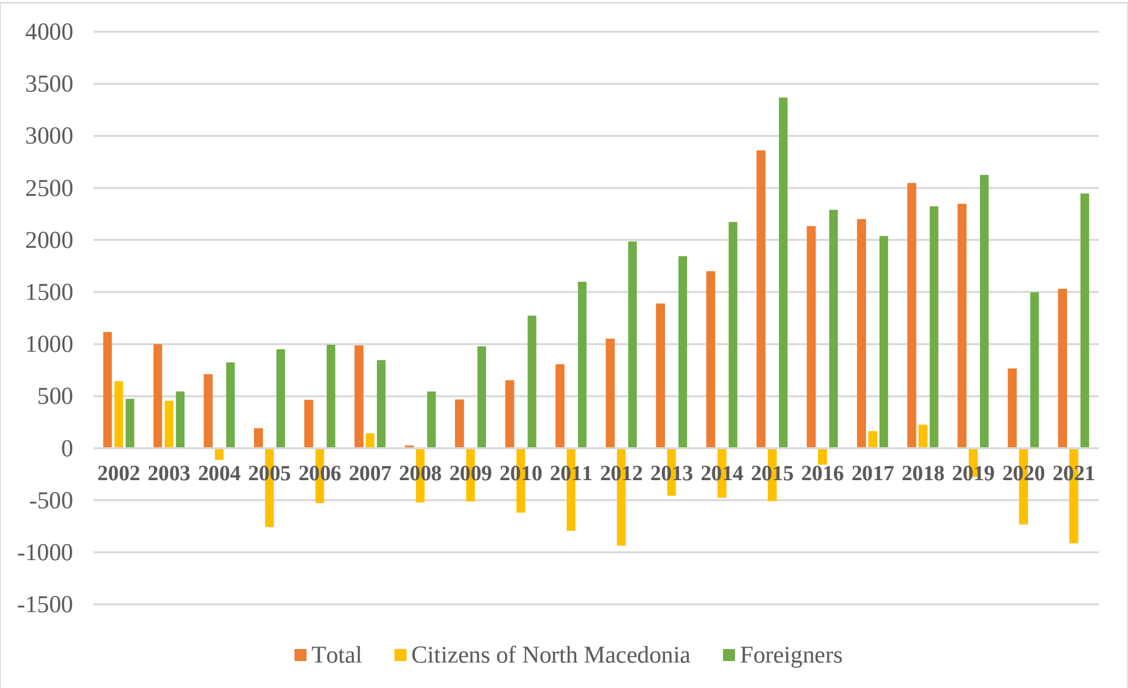

Figure 4. Net migration (total, citizens of North Macedonia and foreigners) for the period 2002-2021

The Pelagonia region is the only one that has maintained a positive net migration (only when it comes to citizens of North Macedonia). The other regions have oscillating negative net migration. Unlike the previous analyzed years, in 2021 in the Skopje region, the international migration flows have a high value. A major portion of the rural population still chooses to relocate to the cities, while the number of people from the rural areas migrating outside of the country is decreasing. Urban municipalities have a significant outflow of population abroad.

The combination of low fertility and emigration exacerbates the effects of aging, as it is young people who are more likely to migrate. This creates a double "whammy" in terms of population aging, as young people are also potential parents, so their leaving further reduces the size of the new generations [13].

Given the fact that demographic change has a long-term impact on the economy and all other aspects of society, present internal and international migration trends can be regarded as negative, with the prospect of widening regional disparities in population distribution and structural features. The size and characteristics of the working-age population are defined by such creators of the population age structure, which also serves as the foundation for investment, regional and economic development, and economic sustainability in certain locations.

ANALYSIS OF THE POPULATION AGING IN NORTH MACEDONIA

The age structure of the country's population changed dramatically after World War II. From its prior status as a "young" country in 1953, with a share of 47,4% of young people and only 8.2% of the senior population, in seven decades, the situation has significantly changed.

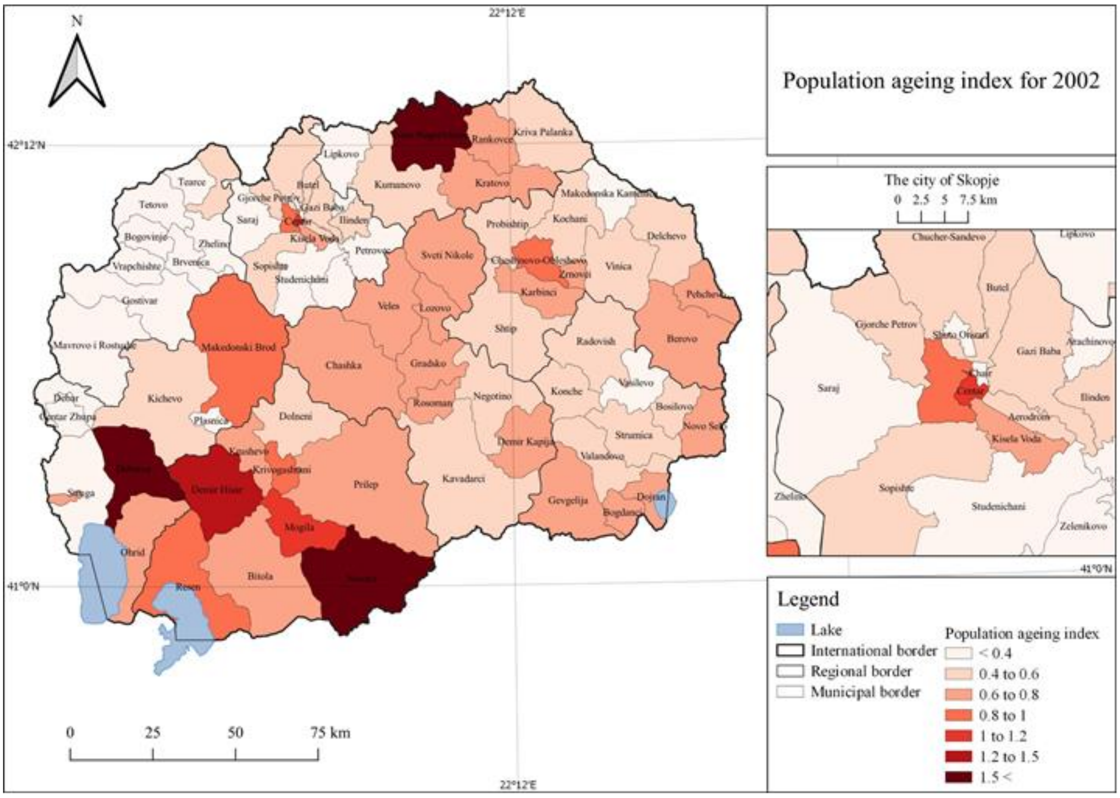

Figure 5. Population aging index for 2002

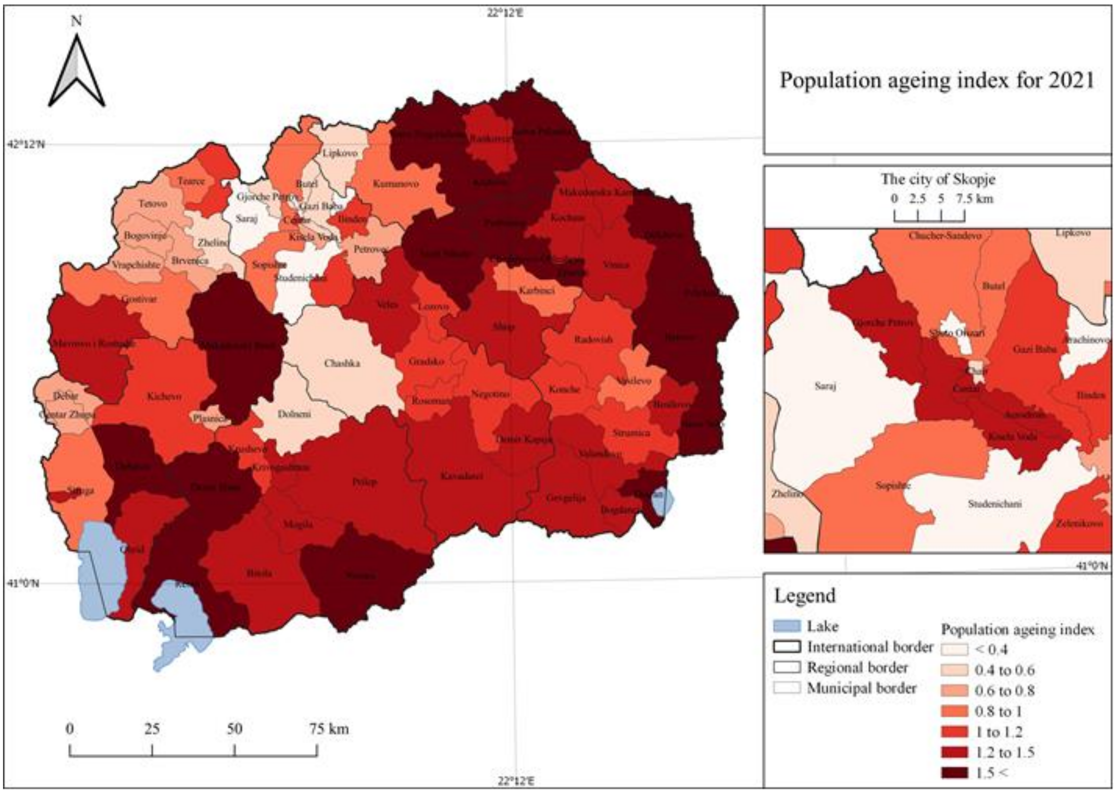

Figure 6. Population aging index for 2021

The decrease in the share of the young population from 29.3% in 2002 to 22.6% in 2021, as well as the increase in the share of the old population from 15% to 24% in the same period, confirms this. Simultaneously, the population aging index grew from 0.51 to 1.06, and the average age increased from 34.6 to 40.3 years, indicating that the population in North Macedonia has reached a deep demographic old age.

Displacement to the border of older age is evident in all regions. The Skopje region, where a higher number of births and share of young people are present as a result of the increased immigration of young people, has the smallest decline in the share of the young population. The evident decline in the birth rate and the emphasized emigration contributed to the decline in the participation of the young population even in the Polog and Northeast regions. On the other hand, the share of the old population increased in all regions. In 2021, the average age of the population in the Polog region, Skopje, the Northeast, and the Southwest regions is lower than the state average, whereas Vardar, Pelagonia, the East, and the Southeast regions have an average age of over 40 years.

The Pelagonia, East, and Southeast regions are "the oldest", although the Polog region has characteristics of a "younger" region based on the share of young and old population, the shift from the stadium of a threshold of demographic age to a stage of demographic aging is visible. From 2002 to 2021, the population under the age of 19 decreased by -35% in urban municipalities, by -33.9% in rural municipalities and by -9.5% in the municipalities within the city of Skopje, with the highest decrease of -20.3 % in the municipality of Gazi Baba, and a decrease of -17.1% in Gjorche Petrov. At the same time, the population over 60 years of age increased by 47% in the urban, 25% in the rural, and 58.2% in the municipalities of the city of Skopje. Among the municipalities of the city of Skopje, the largest increase in the elderly population is evident in the municipality of Aerodrom (123%), Shuto Orizari (105%), and Gjorche Petrov (90.2%).

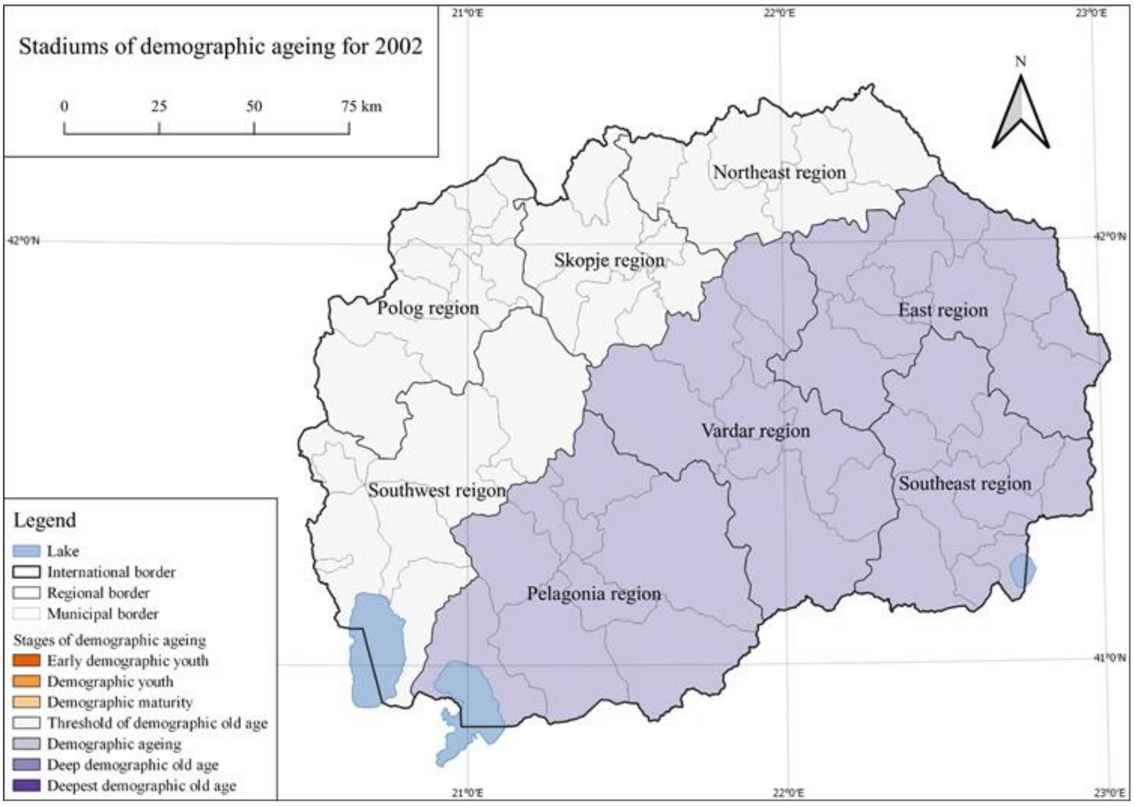

Figure 7. Stadiums of demographic age by regions 2002

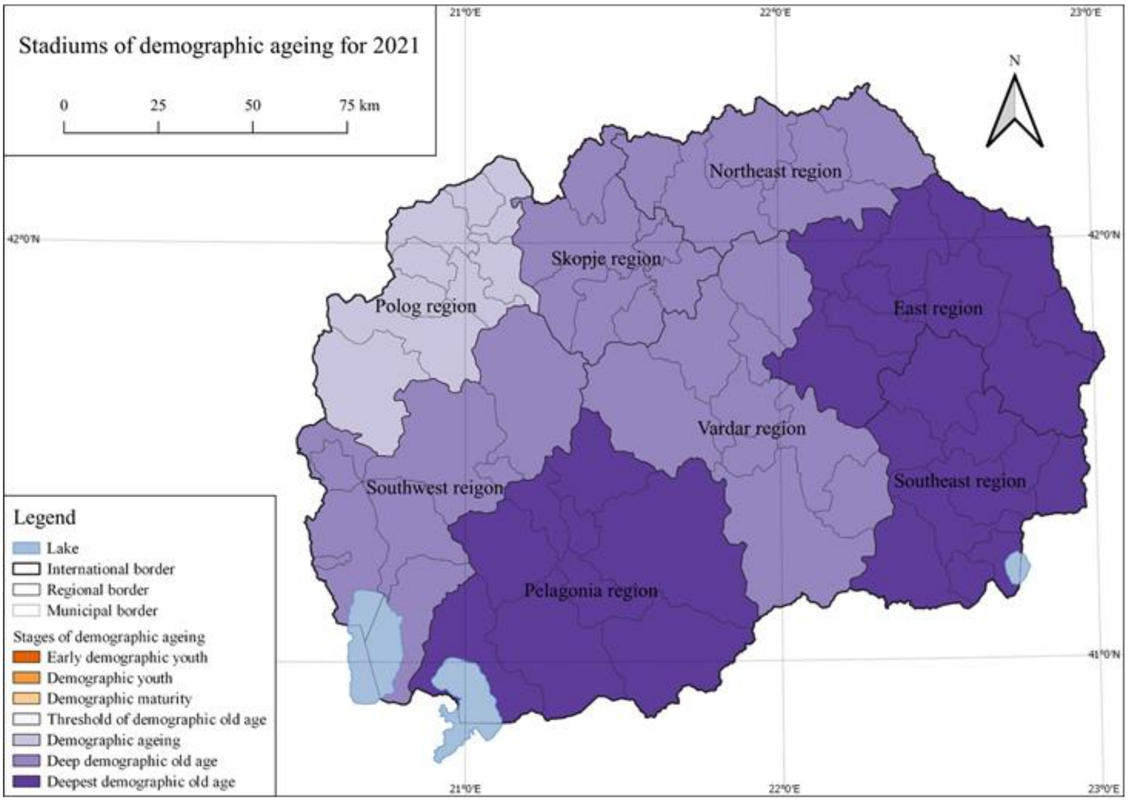

Figure 8. Stadiums of demographic age by regions 2021

The process of population aging is due to greater life expectancy, but it is also because of the decrease in the number of births on the other hand. As a result, the population is aging "from above" due to a decrease in the inflow of new young generations. The number of generations born in the 1960s and 1970s will migrate into the elderly group in the next 10 to 20 years, increasing the elderly population's share of the total population.
Hence, the few relatively "young" population zones and other locations where demographic aging is strongly ingrained, stand out. As a prerequisite for economic development, this phenomenon highlights the question of current demographic resources and the consequences that would be expected on the volume and characteristics of the labor contingent.

CHARACTERISTICS OF THE WORKING-AGE POPULATION AS A BASIS FOR THE ECONOMIC DEVELOPMENT

Labor supply is essential to economic growth, though the reality is far more complicated and less demographically defined. A shrinking working force does not necessarily cause problems in the labor market, because productivity is far more important than size. But in the long run, population aging will undoubtedly present a threat to economic growth, because it leads to a decline of the working-age population and aging of the labor force [62].
The variables for determining the volume and composition of the labor contingent are defined by its scope and structural characteristics, which determine its dynamics.
When looking at the population aged between 15 and 64 years old, after World War II, can be noted pronounced increase that lasted until the 1980s and the 1990s of the 20th century. This age group maintains a consistent volume and share in the overall population of over 2/3. This is related to the constant inflow of population in this age group which comes as a result of the relatively higher birth rate and the presence of several generations born in the 1950s and 1960s of the last century that will continue to participate in the increased volume of the working-age population for a long time. After 2002, however, a more significant change in the labor force is expected, both in volume and age, due to the decline in inflow and increased outflow of these generations, as described earlier in the text. "It is common knowledge, as an empirically verified law, that as the birth rate falls, the share of the working-age population in the total increases. There is an aging process of the labor force, recorded in the later stages of the demographic transition (central stage and late-stage)" [51]. The economic implications of population aging are mostly reflected in the impact of the volume of young individuals entering the working age. In particular, the share of the incoming age groups of 0 to 4, 5 to 9, and 10 to 14 years nearly doubled decreased from 1961 to 2002. On the other hand, the share of the age groups of 50 to 54, 55 to 59, 60 to 64, and over 65 years doubled their involvement throughout the same period.
The share of the working contingent in the total population amounts to 68.3% in 2002 and 65.9% in 2021. During this time period, it reduced its volume by 171,317 inhabitants or -12.4%, primarily in the age group of 15 to 29 years (-32%). On the other hand, there is greater growth in the age groups of 55 to 59 years (32,518 individuals) and 60 to 64 years (34,973 people). Negative growth in the working-age population is predicted due to the reduced inflow expected in the next five years, which will not be able to compensate for the outflow.

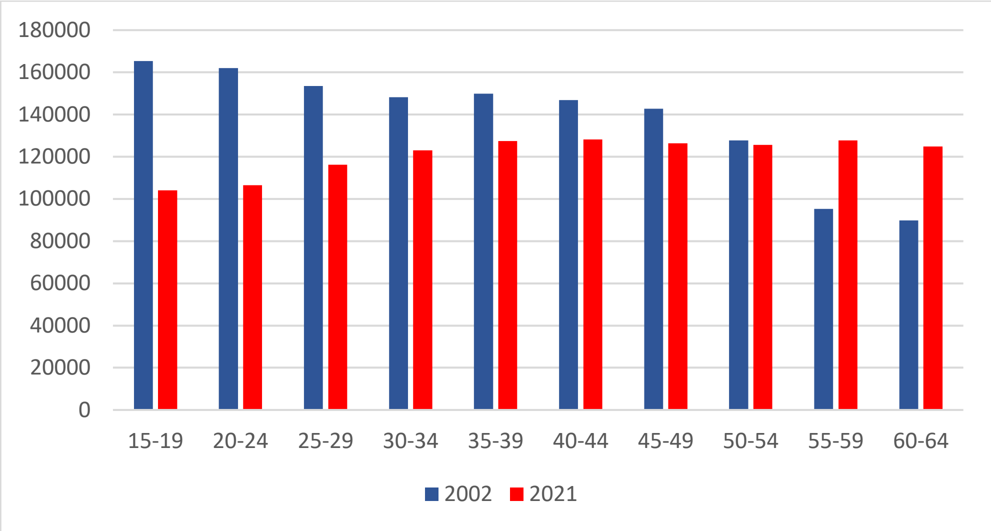

Figure 9. The working-age contingent in 2002 and 2021

In addition to the changes in volume, there are noticeable shifts in the aging of the labor force. In the analyzed period, the population aged 15 to 29 years, declined from 34.8% to 27%, and the population aged 30 to 44 years decreased from 32.2% to 31.3%. The share of people aged 45 to 59 years old has risen from 26.5% to 31.4%. In particular, we have a larger increase of the population in the older age group of the working-age contingent, in comparison to the younger i.e., the working-age population contingent from 40 to 64 years increases with the highest average annual growth rate of 0.3%, compared to the total population (-0.5%) and the young working-age population aged between 15 and 39 years (-1.6%). This unfavorable trend among the young age groups of the labor force only highlights the country's demographic resource constraints and rapid aging of the labor force in the coming years. The growth in the median age, as an adequate measure, given that "it is not affected by the extreme values of the population displacement by age", [9], confirms the aging of the labor force. The labor force median age has risen from 35.1 in 1981 to 35.3 in 1994; 36.6 in 2002, and 40.4 in 2021. "The effects of the aging labor force will be felt in the aging of the active population, as well as the direct and indirect repercussions on the labor market" [51].

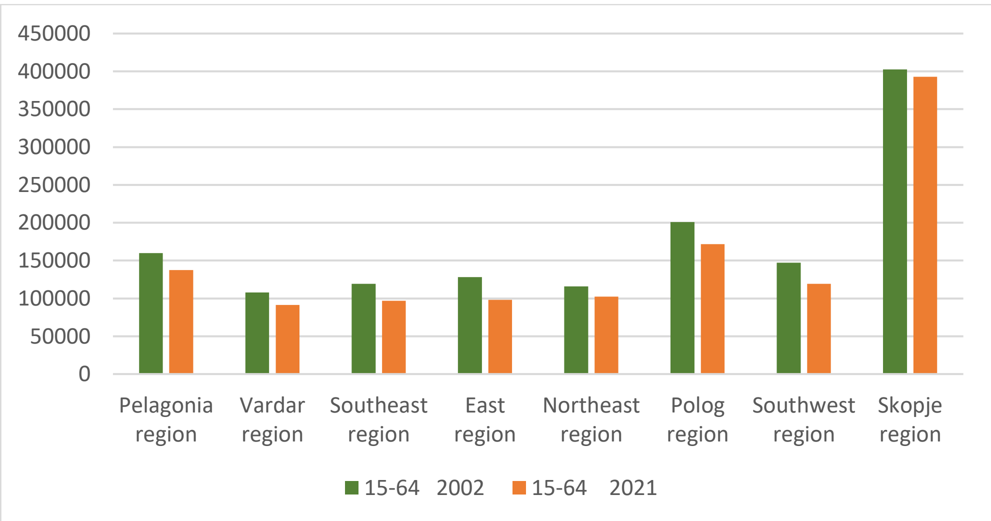

Figure 10. Reduction in the working-age contingent in 2021 compared to 2002

A decrease in the working contingent can be noticed in all regions, with the Skopje region having the smallest decrease of -2.4%, mainly due to the increase in the working contingent in several municipalities (Studenichani by 27.7%; Shuto Orizari by 17.1%; Sopishte by 15.9%; Arachinovo by 15.5% and Saraj by 11.3%).

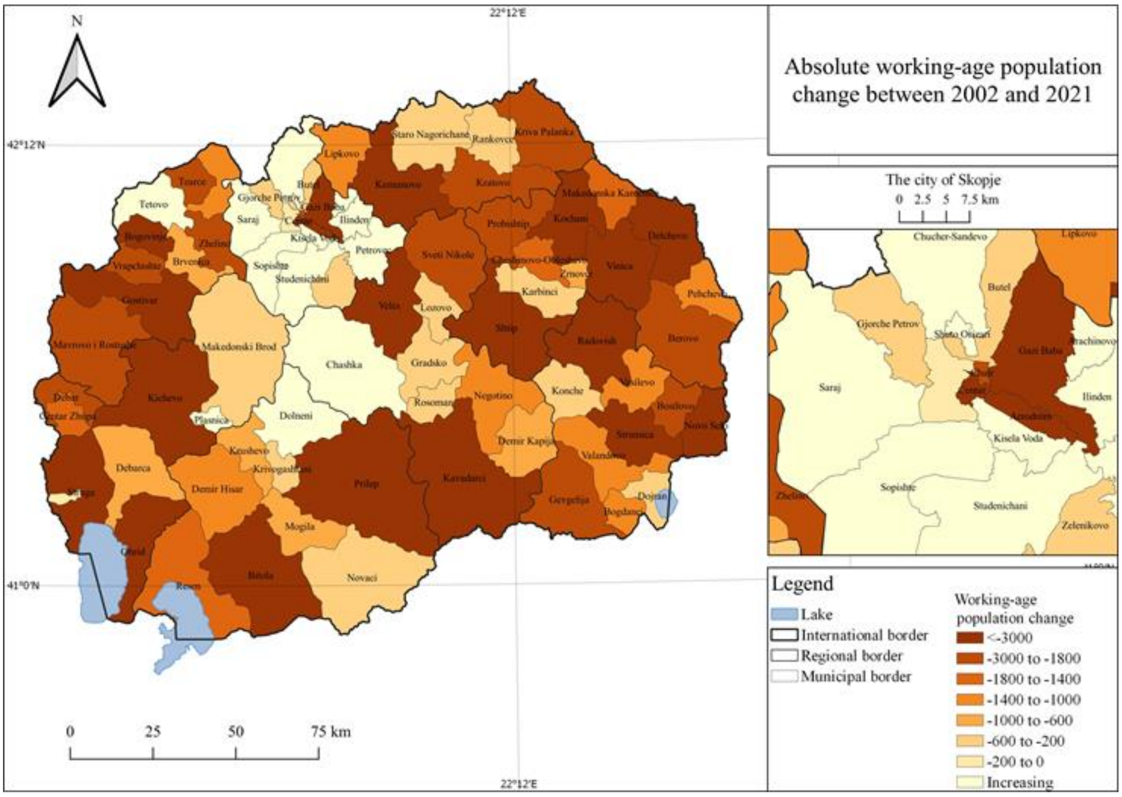

Figure 11. Absolute working-age population change between 2002 and 2021

Due to the increased inflow of new generations into the working-age population, these municipalities will be able to compensate for the reduced birth rate, migration, and outflow of generations for some time. However, because of the noticeable demographic depopulation in the other municipalities, it will be impossible to renew the labor force after 2026, but especially after 2031.

In terms of volume and generational replacement, the Skopje region will maintain longer, owing to the significant concentration of population that has resulted from immigration.

In that period between 2002 and 2021, the working-age population in urban municipalities declined by 128,550 individuals, 28,647 in rural municipalities, and 14,120 in the municipalities of the city of Skopje. These points to a serious problem especially in rural areas, which have long been weakened as a result of strong industrialization, spontaneous de-agrarization, and undirected urbanization, and are no longer economically or infrastructurally attractive to keep the existing young and mature population. In 2021, rural municipalities account for only 17.4% of the overall population of the country, with the Polog region accounting for one-third. Four municipalities in the Polog region, along with Studenichani and Arachinovo from the Skopje region, will be the main carriers of the total rural population in the next ten years, contributing to the replacement of the working-age population. The apparent fall in generational replacement points to the lack of demographic resources required for economic development, a concern in all rural municipalities.

Table 2. Dynamics of the working-age population, by regions (NUTS 3)

region	**Year**	**Inflow**	**Outflow**	**Increase in the working-age population**	**Increase rate**	**Replacement rate**
RN Macedonia	2021-26	105508	124795	-19287	-1,6	84,5
	2026-31	109318	127752	-18434	-1,5	85,6
	2031-36	96521	126444	-29923	-2,5	76,3
Skopje	2021-26	36588	35113	1475	0,4	104,2
	2026-31	39658	37646	2012	0,5	105,3
	2031-36	36582	40006	-3424	-0,9	91,4
Polog	2021-26	15962	15670	292	0,2	101,9
	2026-31	16547	17705	-1158	-0,7	93,5
	2031-36	14370	17539	-3169	-1,9	81,9
Southwest	2021-26	9953	12800	-2847	-2,4	77,8
	2026-31	9891	12772	-2881	-2,5	77,4
	2031-36	8524	12182	-3658	-3,2	70,0
Pelagonia	2021-26	11448	16197	-4749	-3,5	70,7
	2026-31	10896	15359	-4463	-3,4	70,9
	2031-36	9148	14335	-5187	-4,0	63,8
Vardar	2021-26	7390	10612	-3222	-3,5	69,6
	2026-31	7625	10367	-2742	-3,1	73,6
	2031-36	6620	9935	-3315	-3,9	66,6
Northeast	2021-26	8901	10174	-1273	-1,2	87,5
	2026-31	9126	10764	-1638	-1,6	84,8
	2031-36	7953	10528	-2575	-2,6	75,5
East	2021-26	7307	12555	-5248	-5,4	58,2
	2026-31	7276	11711	-4435	-4,8	62,1
	2031-36	6144	10698	-4554	-5,2	57,4
Southeast	2021-26	7958	11674	-3716	-3,8	68,2
	2026-31	8299	11428	-3129	-3,4	72,6
	2031-36	7180	10420	-3240	-3,6	68,9

Source: Authors' calculations using SSO population census data and the database

Table 3. Dynamics of the working-age population in the urban, rural municipalitiesand the municipalities within the city of Skopje

	Year	Inflow	Outflow	Increase in the working-age population	Increase rate	Replacement rate
rural	2021-26	21131	19897	1234	0,6	106,2
	2026-31	21921	21680	241	0,1	101,1
	2031-36	18633	21942	-3309	-1,6	84,9
urban	2021-26	53817	73706	-19889	-3,0	73,0
	2026-31	54146	72800	-18654	-2,9	74,4
	2031-36	47198	68754	-21556	-3,5	68,6
Municipalities in the city of Skopje	2021-26	30560	31192	-632	-0,2	98,0
	2026-31	33251	33272	-21	0,0	99,9
	2031-36	30690	34947	-4257	-1,3	87,8

Source: Authors' calculations using SSO population census data and the database

At the same time, the situation implies unused natural resources, restricted revitalization opportunities, and rural areas' demographic and economic insufficiency.
Demographic and economic development would point to four possible scenarios based on the analysis and projections of the trend of behavior on the political scene.

Scenario 1 - Progressive scenario

North Macedonia's aspiration for European Union membership, among other things, aims to open up opportunities for economic development and contribute to a better demographic picture of the country. Assuming that the country's EU membership commitments are met on time, the hopes for a more stable economic condition, increased investment prospects, more jobs, a better social image of the country, and poverty reduction are achievable. There are numerous grounds to expect a decrease in emigration from the country, as well as retention of a young, working-age population and enough labor force to satisfy the demands of supplying adequate demographic resources for the expected increasing economy. It is a step toward achieving greater balance in terms of even population distribution by age and gender, as well as economic development.

Such preconditions for a better demographic picture will serve as a firm basis for a new trend in the scope and characteristics of the working-age population, as well as new economic development potential.

This progressive scenario is primarily associated with urban municipalities. On the other hand, rural municipalities are anticipated to receive investments to improve their quality of life and raise their population's living standards, reroute migration, and stimulate daily and cyclical migration. The retention of the population and the facilitation of population development are merely a starting point for promoting economic development.

Scenario 2 - Regressive scenario

The working-age population from rural municipalities is expected to continue to move mostly to urban settlements and abroad because of the current conditions of spatial and economic organization and infrastructural equipment of the rural area. Such emigration, combined with the lower birth rate, will surely result in significant population loss and aging in this area. In the few rural municipalities that have a higher birth rate than other ones, the losses of the emigrating population will be compensated in the next few years, while the effects will be seen by the end of this decade when the impact of reduced birth rates and emigration will be felt.

A continuing outflow of the population is unavoidable given the weaker economic base in urban municipalities such as Delchevo, Makedonski Brod, Krushevo, Valandovo, Bogdanci, Pehchevo, Kratovo, Sveti Nikole, and others. In this period, the consequences will be visible even in the municipalities with a larger population such as Gostivar, Tetovo, Kumanovo, etc. Thus, demographically weakened and with population aging, municipalities will have real difficulties in demographic and economic sustainability and development.

Scenario 3 - Optimistic scenario

The optimistic scenario depicts a future in which the country will be attractive to foreign immigrants as a potential EU member. Larger investments would produce more job possibilities and bring employment and unemployment rates closer to those in European Union countries.

The optimistic scenario allows us to observe the advantages in terms of demographic situations, such as moderating current and preventing further depopulation.

This circumstance will help to prevent the rapid aging of the total population and the working-age population, as well as economic development predispositions. Serious opportunities for safe investments, product placement, income, and the possibility of a higher standard will be realized.

Scenario 4 – Pessimistic scenario

Assuming that North Macedonia joins the EU, deviations from the desired trends in terms of economic development are possible. Namely, the opening of the opportunity to be a part of the EU brings the privilege of looking for a job in the member states, where the job earnings are higher. Therefore, the expectations for a mass outflow of the labor force and greater acceleration of the population aging process are realistic. After all, these scenarios have already been recorded in countries like Croatia, Bulgaria, etc.

CONCLUSION

The parallel between demographic aging and labor force features as a basis for economic development planning, highlighted the current poor position, which, sadly, is anticipated to worsen under current economic and political conditions. The population in the country is in the stage of deep demographic old age and only a few municipalities stand out as young zones, whose "youth" is a result of greater birth rates in recent years or immigration, as is the case in certain municipalities within the Skopje city area.

The extent and features of the working-age population are directly impacted by this circumstance. Its volume lowers and records aging.

After 2026, the problem with a lack of labor force by volume and age characteristics will become increasingly severe in all municipalities and regions. This will be more pronounced in rural municipalities, as their material and institutional infrastructure makes them unattractive for maintaining young people or attracting new people and investments in the economy. At the same time, unfavorable changes in the working-age population will have an impact on the current labor force (employed and unemployed population), while the outflow of the labor force will cause skills shortages in the Macedonian labor market [44].

In a country facing all these economic, political, and social issues, the problem of replacing generations of the labor force will have severe implications for the country's future economic development. The problem is much worse when we first consider the young population's tendency to migrate to societies with developed economies and higher incomes, which are "psychologically" imposed on the population as countries synonymous with standard and earnings, and second, the state's inability to retain or attract such a population due to non-competitiveness both on economic power, as well as living conditions. There seems solution to population aging, and the remedies for its negative effects need to be sought among non-demographic policies [17].

In the current conditions, the negative sign of population aging gives an alarm to governments in order to consider changes in social, demographic [41], and economic policies. Among the social measures, it is necessary to define the social problems and needs of individuals and to overcome social exclusion, equal education opportunities, acquisition of skills, continuous i.e., lifelong learning, life, and work.

Investments in the business sector are highly needed, then, creating conditions for more jobs and higher personal income, which as a motive will contribute to retaining the population and would have a positive impact on labor resources. It is extremely important to strengthen the agricultural sector and the agro-industry, benefits packages for the agricultural production development, which is the basis for strengthening the economy considering the country's agrarian resources, opportunities for balanced regional development, economic but also demographic strengthening of rural municipalities, etc. At the same time, society must get rid of the devaluation of the values of the individual, the great partisanship, the inaccuracy of the institutions, and the poor environmental

conditions, so that young people may decide to choose their own country as a place where they will build their future.
This situation highlights the urgent necessity to join the EU as soon as possible and invest in critical sectors, as well as the unavoidable need to adapt to European laws, rules, and norms. This would surely avoid creating a "depopulation and destitute country", which would undoubtedly result in a new problem in the region and beyond.

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ATTITUDES ABOUT THE POSSIBILITY OF USING STATE TOURIST VOUCHERS: A CASE STUDY OF VOJVODINA (NORTH SERBIAN PROVANCE)

DOI: https://doi.org/10.18509/GBP23113t
UDC: 347.748:338.486.1.027(497.11)

Jelena Tepavčević
Milan Bradić
Vuk Garača
Svetlana Vukosava
University of Novi Sad, Faculty of Science, Department of Geography, Tourism and Hotel Management, **Serbia**

ABSTRACT

Since 2014, the Serbian Government has been implementing the policy of issuing tourist vouchers as a form of incentive for the social tourism and increasing domestic tourism demand development, which has been in constant decline over the past decade. As a form of domestic tourism incentive, vouchers are used in many countries of the world, but also in countries in neighborhood (Romania, Hungary, Croatia, etc.).When it comes to the Republic of Serbia, clear criteria are provided for determining the part of the population in the total structure of the population, which has the right to use the given funds. In general, we are talking about pensioners, students, unemployed, employees with lower personal income and other sensitive social categories. The aim of the paper is to find out to what extent the inhabitants of Vojvodina are interested in using these funds for the tourist trips' realization in the country. The task is to identify the demographic parameters of potential tourist vouchers' users, as well as the place and method of their realization. The survey method was used for data collection, and t-test and ANOVA for determining respondents' attitudes towards travelling around Vojvodina depending on their sociodemographic characteristics.

Keywords: social tourism, vouchers, user structure, Republic of Serbia, Vojvodina.

INTRODUCTION

The idea of social tourism has its roots in the social democratic ideal of a just and fair society, where equality of access to leisure travel is promoted due to its advantages for both individuals and families [1]. Social tourism is defined as travel with a higher moral standard [2]. In developed societies, social tourism can be an effective tool for policymakers to work toward greater equality in fair access to full citizenship rights and social inclusion. It also offers the possibility of cost savings, as a happier and more equal society requires less social support, healthcare services, and other services. Last but not least, social tourism can be a highly effective growth driver for the domestic tourism industry, fostering greater sustainability and resilience in the industry. This is crucial in light of the current pandemic, which poses a serious threat to the tourism and hospitality sectors in many countries around the world [3]. The term "social tourism" has many definitions [2], but the most recent definitions emphasize that it refers to "all activities, relationships and phenomena in the field of tourism resulting from the inclusion of otherwise disadvantaged and excluded groups in participation in tourism. The inclusion of these groups in tourism is made possible through financial or other interventions of a well-defined and social nature” [4]. In spite of the fact that there are three main social tourism implementation schemes that can be found across Europe, each nation frequently uses two or more combinations, illustrating the difficulties in comparing social tourism-related concerns. Holiday vouchers can be used to choose commercially operated tourist accommodations in some countries (such as Hungary and Romania), while in other countries (such as France), they can be used to gain access to socially operated tourist facilities [1]. Employees are given valuable tickets known as tourist vouchers to help them pay for their domestic travel-related expenses while on vacation [5]. Most frequently, a "voucher" is a piece of paper that entitles the owner to receive discounts [6]. It can also be redeemed for a good or service offered by a representative [7]. In general, social vouchers make it easier for some social groups to access specific services or goods [8]. The primary attributes of social vouchers include being governed by a legal framework, having a constrained geographic scope, being offered at the request of a private or public entity, providing access to specific service providers, being simple to use, and not being convertible into cash [9]. The purpose of the study is to determine the level of interest in using these funds to encourage tourism vacations in Vojvodina (Serbia) among locals. The assignment is to determine the demographic characteristics of possible tourist voucher users, as well as the location and mode of realization.

THE USE OF TOURIST VOUCHERS IN THE WORLD, IN THE EUROPEAN UNION AND IN THE REPUBLIC OF SERBIA

According to the Social Vouchers International Association [10], which was established in Belgium in 2017, social vouchers have been developed in 40 countries, 19 of which are EU countries, over the past 50 years and include the following categories: (1) food and meal vouchers, (2) personal and household services vouchers, (3) transport vouchers, (4) leisure vouchers, (5) childcare vouchers, (6) culture vouchers and (7) eco vouchers [9]. Four goals were pursued with this action: (1) promoting domestic tourism; (2) reducing seasonality; (3) addressing the high level of informality in this sector; and (4) lowering emigration to Western nations. In a nutshell, the goal of this legislation was to provide employers a choice that would enable them to improve the real income and welfare of their workers at a minimal additional financial expense. By providing these incentives, employers may be able to decrease employee churn, a significant issue for many businesses, particularly small and medium-sized enterprises (SMEs), and boost employee enthusiasm and productivity [5]. The goal of leisure vouchers is to make it easier for citizens to use sporting and wellness facilities, as well as healthy living options [9]. In France, the "cheque vacances," a tool designed to make it easier for workers to use vacation days, and the founding of a national agency for chèques-vacances introduced the idea of vacation vouchers in 1982. The Czech Republic, France, Greece, Hungary, Romania, and Slovakia are currently EU members that use vacation vouchers. More recently, the governments expanded the use of vouchers in response to the rapidly rising costs of essentials and energy by providing social vouchers to poor households so they could purchase staple foods, as well as to students so they could purchase food, school materials, and clothing [11]. As for the Republic of Serbia, vouchers have been in use since 2014 and their value is €45, while last year 2022 the value of vouchers was €120. About 200.000 citizens used this opportunity last year. And in the current year 2023, the Government of the Republic of Serbia, i.e. the Ministry of Tourism and Youth, continues to support the development of domestic tourists and the inclusion of wider social strata in tourist trips, by subsidizing through vouchers the following social groups: pensioners, unemployed, beneficiaries of the right to allowance for assistance and care of others persons, employees with incomes that do not exceed 70,000 dinars per month (about €600), military invalids, holders of agricultural holdings, students and (for the first time) persons over 65 years of age who do not exercise the right to a pension [12]. Table 1. shows the tourist vouchers programs in some countries of Europe and the World during the pandemic year 2020.

Table 1. Tourism voucher schemes around the globe

Country/ city	**Measure**	**Source**
Shaoxing (China)	Distribution of coupons to over 1 million Alipay users.	[13]
Taiwan	Tourism vouchers for domestic tourists worth €100 at a cost of €33.3, the rest is subsidized	[14]
Ireland	“Stay and Spend” initiative: a government subsidy of €125 for €625 spent on accommodation, food and (non-alcoholic) beverages	[15]
Iceland	€34 for Icelandic residents aged over 18 years in order to spend it on domestic accommodations, travel related entertainment and food	[16]
Italy	“Holiday Bonus” worth up to €500 for lower-income households.	[16]
Poland	Tourism voucher worth €112 for children under the age of 18.	[17]
Slovenia	A €200 staycation voucher for residents aged over 18 years and a €50 voucher for residents younger than 18 years	[18]
Lithuania	Vouchers of up to €200 for domestic health workers	[16]
Vienna (Austria)	A €50 voucher for every family in Vienna to spend in local Viennese restaurants.	[19]
South Korea	Employees of small companies receive vacation bonuses from the government worth 25% of the total cost of stay	[16]
Thailand	A 50% subsidy for accommodation services for domestic travelers.	[20]

Source: created by the authors based on a literature review

METHODOLOGY

This research was focused on exploring the attitudes of respondents of Republic of Serbia towards the use of touristic vouchers given by the Government of Serbia. The special focus was on their attitudes towards the use of vouchers for traveling in Vojvodina. For the purpose of the research, the questionnaire was created. The first part of the questionnaire consisted of questions related to sociodemographic characteristics of respondents and their travel habits. The questions from the second part of the questionnaire were dedicated to familiarization with social tourism and the use of tourist vouchers for traveling in AP Vojvodina. The respondents use five-point Likert scale for expressing their level of agreement with items towards traveling around Vojvodina (1 – totally disagree, 5 - totally agree).

RESULTS

Sample description

The research was conducted from October 2022 to January 2023 and it was carried out on the territory of the Republic of Serbia. The target group consisted of respondents who have the right to use the voucher, namely: pensioners, pupils, students, unemployed people, beneficiaries of special cash benefits and temporary benefits, beneficiaries of the right to an allowance for assistance and care for another person, and all workers whose salary does not exceed 70,000 RSD. The total number of respondents was 252 and 143 (56,7%) were females. The most of respondents belong to age category up to 25 (104, 41,3%) and have completed high school (152, 60,3%). The most of them are married (99, 39,3%), followed by single respondents (72, 28,6%). When it comes to employment status, the most of respondents are employed (117, 46,4%), followed by students (75, 29,8%). Since most of the respondents are under 25 years of age, and a large number of them are still students, it is not surprising that the majority of respondents have low incomes, i.e., up to 38,000 RSD (111, 44%). By using crosstabulation analysis it was determined that the most of respondents who earn less than 38.000 RSD are students (55%) followed by unemployed (17,1%) and pensioners (14,4%).

Table 2. Characteristics of respondents

Characteristics of respondents	**Frequency**	**Characteristics of respondents**	**Frequency**
Gender		**Employment status**	
Male	109	Student	75
Female	143	Employed	117
Age		Unemployed	29
Up to 25	104	Retired	31
25 – 35	44	**Income**	
36 – 45	33	Less than 38.000 RSD	111
46 – 55	34	38.001 – 50.000 RSD	83
Over 55	37	50.001 – 70.000 RSD	58
Education level		**Frequency of traveling**	
Primary school	7	Never	7
High school	152	Rare	71
College	28	Sometimes	125
Bachelor’s degree	54	Often	49
Master’s degree	8	**Are you familiar with social tourism?**	
PhD	3	Yes	90
Marital status		No	81
Single	72	I am not sure	81
In a relationship	56	**Are you familiar with the offer of social tourism?**	
Married	99	Yes	55
Divorced	15	No	124
Widowed	10	I am not sure	73

Source: results of research

Students’ sources of funding are scholarships and loans, while some unemployed people have a certain compensation from the state, which explains the low incomes. Regarding the frequency of traveling, most of them answered that they travel sometimes (125, 49,6%). Respondents were also asked about their familiarity with social tourism and the offer of social tourism. The majority of respondents are not familiar with social tourism (81, 32,1%) or are not sure what it is (81, 32,1%). Regarding offer of social tourism, the most of them are not familiar with offer of social tourism (124, 49,2%). Characteristics of respondents are shown in Table 2. Table 3. shows the results of descriptive statistical analysis. The item that got the highest score is “I will use vouchers for traveling around AP Vojvodina in the future” (3.39), while the item with the lowest score is “I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers” (1.75). Low scores of first two items indicate that people are not very familiar with the offer and variety of accommodation in AP Vojvodina, which is an aspect that needs to be improved.

Table 3. Results of descriptive statistical analysis

Item	Arithmetic mean	Std. Deviation
I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers.	1.75	1.04433
I believe that the offer of accommodation in AP Vojvodina that accept vouchers is diverse.	2.30	1.21590
I am interested in using vouchers for traveling around Vojvodina.	3.29	1.48333
I will use vouchers for traveling around AP Vojvodina in the future.	3.39	1.26765

Source: Authors’ research

T-test according to gender

In Table 4. are presented results of t-test according to gender. The findings showed that women express statistically significant higher intention to use vouchers for traveling around Vojvodina than men (t=-3.326, p=0.001).

Table 4. T-test according to gender

Items	Male	Female	t	p
I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers.	1.71	1.78	-0.525	0.600
I believe that the offer of accommodation in AP Vojvodina that accept vouchers is diverse.	2.22	2.36	-0.928	0.354
I am interested in using vouchers for traveling around Vojvodina.	3.03	3.49	0.190	0.016
I will use vouchers for traveling around AP Vojvodina in the future.	3.09	3.62	-3.326	0.001*

Source: results of research, *p<0.005

ANOVA according to age, education level, marital status, income level and frequency of traveling

Analysis of variance ANOVA was conducted to determine if characteristics of respondents (such as gender, age, education level, marital status, income level and frequency of traveling) have effects on their attitudes towards traveling around Vojvodina. Age of respondents was the first tester parameter. The results mainly showed that there are no differences in attitudes of respondents according to their age. Differences in attitudes were found only for the item “I am interested in using vouchers for traveling around Vojvodina”. In order to determine between which groups the answers differ, LSD post-hoc was applied. The results showed that respondents from age group “26-35” expressed statistically significant higher interest for traveling around Vojvodina than respondents from age group “Over 55”.

Table 5. ANOVA according to age

Items	Age groups					F	P	LSD
	Up to 25	26-35	36-45	46-55	Over 55			
I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers.	1.75	1.82	1.94	1.47	1.73	0.928	0.448	-
I believe that the offer of accommodation in AP Vojvodina that accept vouchers is diverse.	2.37	2.23	2.30	2.15	2.35	0.262	0.902	-
I am interested in using vouchers for traveling around Vojvodina.	3.46	3.23	2.91	3.74	2.84	2.601	0.037*	1>5
I will use vouchers for traveling around AP Vojvodina in the future.	3.51	3.33	3.52	3.21	3.19	.0.748	0.560	-

Source: results of research, *p>0.05

When it comes to educational level, it was found that there are statistically significant differences in attitudes towards item “I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers”. LSD-post hoc test showed that respondents with completed only high school express lower knowledge about accommodation offer in Vojvodina than respondents with college and master diploma. The results of analysis are presented in Table 6.

Table 6. ANOVA according to educational level

Items	Educational level						F	P	LSD
	Primary school	High school	College	Bachelor	Master	PhD			
I am familiar with the offer of accommodation in AP Vojvodina that accepts vouchers.	1.86	1.65	2.11	1.63	2.88	2.00	3.099	0.010*	2<3,5
I believe that the offer of accommodation in AP Vojvodina that accept vouchers is diverse.	2.29	2.20	2.29	3.12	3.00	2.30	1.248	0.287	-
I am interested in using vouchers for traveling around Vojvodina.	3.00	3.35	3.04	3.17	4.00	4.00	0.841	0.521	-
I will use vouchers for traveling around AP Vojvodina in the future.	3.43	3.55	2.81	3.22	3.63	3.00	1.909	0.093	-

Source: results of research, *p>0.05

The results of analysis of variance ANOVA showed that there are no statistically notable differences in attitudes of respondents towards travelling around AP Vojvodina according to their marital status, income level and frequency of travelling, therefore, the results are not shown in a table.

CONCLUSION

Social tourism is a very important concept for the reason that it enables various social groups to get involved in tourist trips. According to research, socially excluded people benefit significantly from tourism involvement, and social tourism can result in a variety of positive effects for social tourists, social and welfare policies, and society. For example, for low-income families, social tourism provides opportunities for repairing and building relationships [21]. For older people, social tourism can improve their social opportunities. Children can benefit from learning and experiences [22], while people with disabilities can get opportunities to improve their health and get access to opportunities [23]. That is why social tourism is tied to the concept of “Tourism for all”.

This study was focused on examining the attitudes towards using vouchers for traveling around Vojvodina. The results of this study showed the level of the familiarity of the population of Serbia with the concept of social tourism, that is, the use of tourist vouchers. What can be concluded from the obtained results is that the respondents are not sufficiently familiar with the concept of vouchers for traveling around Serbia. Given that the emphasis of this research was on trips around Vojvodina using vouchers, the respondents' attitudes were investigated depending on their socio-demographic characteristics. Descriptive statistical analysis showed that there is interest in traveling around Vojvodina to a certain extent, while the t-test indicated that women expressed a higher degree of interest than men. It can be explained by the fact that literature recognized gender disparities when it comes to traveling. In previous research it was determined that women travel short distances compared to men (e.g. [24]; [25]). Since trips in Vojvodina involve a shorter stay, this can determine the fact that women are more interested than men in this type of travel. Also, it was determined that women generally travel differently than men do in terms of destinations visited, travel objectives, travel distance and method of transportation ([26]; [27]; [28]; [24]). The roles that men and women play in society, which result in differing activity patterns, have been a major factor in explaining these discrepancies. In particular, the division of home responsibilities and labor market dynamics, as males typically travel farther to their jobs than women. Women are more likely to have local part-time jobs near to their homes and tend to have paid employment opportunities that are geographically limited ([29]; [30]). Since traveling around Vojvodina does not require a lot of time, a potential explanation for the obtained results can be found in this, i.e. greater interest of women in traveling around Vojvodina. Age itself, as well as variations in socioeconomic and demographic traits, are the main factors that differentiate older people from younger [31]. This study showed higher interest among young people (up to 25) to travel around Vojvodina compared to older people. The great number of respondents from the age group “up to 25” are students, and due to their low income, they are often limited in choosing the destination for travel. Vouchers are a good opportunity for them to travel a little, which makes them more interested in traveling than others. When it comes to educational level, it was found that respondents with completed high school are less familiar with the offer of accommodation of social tourism than those who have a higher education level.

The results obtained in this research gave an insight into the awareness of citizens of Serbia about the concept of travel using vouchers. Due to the small sample, it is not possible to draw general conclusions about the sociodemographic characteristics of the respondents who would travel to Vojvodina. Thanks to the obtained results, it can be seen that the opportunities for travel and accommodation in Vojvodina are insufficiently promoted, so this is an aspect that should be worked on in the future. A recommendation for future research is to expand the sample, in order to better understand who are the potential users of vouchers for travel in Vojvodina, their gender, age, work status, and the like. Based on this, special offers could be made that would correspond to each market segment, and in this way travel around Vojvodina would be promoted.

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EDUCATIONAL MOBILITY, EXPRESSION OF TERRITORIAL INEQUALITIES. EVIDENCE FOR NORTH EAST REGION, ROMANIA

DOI: https://doi.org/10.18509/GBP23123b
UDC: 314.15-021.23:373.062(498-18)

Victoria Buza
Marinela Istrate
Alexandru Ioan Cuza University of Iași, Faculty of Geography and Geology, Department of Geography, Iași, **Romania**

ABSTRACT

This study aims to analyze the mobility of students assigned to high school in 2022 from the North-Eastern Region, Romania. The decision to choose a particular high school is a complex responsibility: firstly, it depends on the student's intellectual abilities, expressed through the results obtained at the National Assessment Exam, which determines his options in relation to the high school's prestige, location, proximity to home, competition and profile.

Since most of the high school educational offer is located in urban centers and isolated in some rural localities, which have only technological high schools, the pupils must choose wisely the institution, taking into account also the financial strength of the family and the ways of commuting and accommodation. The variety of the specializations, the absorption power of school centers, the competition for the most famous high schools in the region and the mobility potential of pupils outline the earliest large-scale migration flows, between rural and urban, on the intra-county and intercounty dimensions. The results of the flows analysis highlight the proportions of the polarization areas, their attractiveness being influenced both by the number of the population and by the administrative hierarchy within the county.

Keywords: polarization area, educational accessibility, migration flows, high school centers, school offer

INTRODUCTION

In contemporary society, people's existence is largely based on the skills and abilities acquired through education. If at the beginning of the 19th century few children received a formal education, today a good part of the population in developed countries has university education and the concept of "long life learning" is taken into account by the majority of active people [1], [2]. The benefits of education do not only extend to higher labour market earnings and more secure jobs, but also include broader advantages such as better health, greater life satisfaction, reduced criminal behaviour and greater civic involvment [12].

Therefore, the key factor in the development of a society is a high level of human capital, implicitly equal access to education, concepts that are in the attention of educational policies in every country [14]. Access to education services is considered a fundamental right of the individual, however, despite guaranteeing the rights to a free and quality compulsory education, there are currently exclusion phenomena from these basic services, related to factors such as the poverty of the population (which cannot afford the additional costs of these services) and the poor infrastructure, especially in rural areas [7].

As in the case of other countries in Central and Eastern Europe, the Romanian education system went through a period of change that can be categorized as a process of educational transition [25]. This was imposed through a fusion of three main components: (a) the transition from a totalitarian political system to a democratic one; (b) overcoming the deep structural economic crisis by creating a free market; (c) updating and adapting to global changes [13].
According to a recently published material - Education and Training Monitor 2022 - in Romania, the discrepancies between the results of the national exams indicate a structural inequality in the education system [5], [8]. The impact of socioeconomic status on school performance is high and equivalent to approximately 3 years of schooling (ie, children from higher socioeconomic backgrounds have an educational level equivalent to that of children 3 years older, compared to children from lower socio-economic backgrounds). This gap in poor learning outcomes in Romania is the highest in the EU. Overall, inequality within the Romanian education system affects future participation in civic and economic life and inhibits workforce development [29], [30], [31]. In recent years, Romania's teacher policy has focused on improving the recruitment and selection process of future teachers, especially for schools located in rural and economically disadvantaged areas. Reforms and policies aimed at increasing financial incentives and other measures to improve the attractiveness of the teaching carrier. In the current context, even if the quantitative differences between the socio-economically favored students and the disadvantaged ones are fading (in the sense of the number of years of schooling), the qualitative differences (the quality of primary education, methods and teaching resources) are deepening. Socially disadvantaged families, less informed and with a limited educational level and professional training, tend to orient their children toward vocational education and less or not at all towards secondary education [12].
On the other hand, inequalities are natural, and school performance and career are determined, in any society, by the characteristics of the family of origin [26], [33]. The peculiarity of the Romanian educational system is that it strengthens these inequalities, leading to major discrepancies within the society.
The Romanian education system is characterized by a differentiated structure by types of education, courses and specializations. Currently, according to Law no. 56/2019, high school education is mandatory, but this obligation ceases if the student has reached 18 years and has not managed to complete his high school studies (fig. 1).

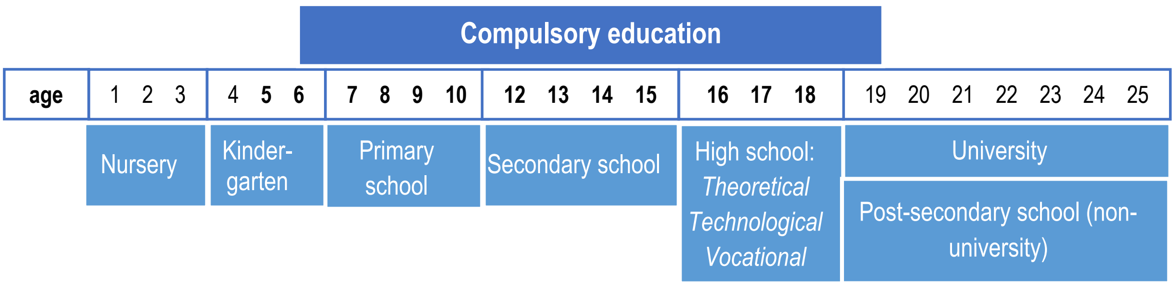

Figure 1. The structure of the education system in Romania.
Source: Education and Training Monitor 2022

The transition from secondary school to high school is a key moment in the school life of students and is often marked by the beginning of the phenomenon of segregation, pupils from different categories of schools having unequal chances to obtain good results [16]. Access to high school is achieved by means of a National Evaluation Exam held in two subjects, Romanian Language and Mathematics, the admission average being crucial for access to high school education and later to university education. All students who graduated from secondary school in that year or those who did not pass the exam in previous years can take this assessment. The schools themselves are administratively differentiated into highly hierarchical types of institutions (national and vocational colleges, theoretical high schools, technological high schools – former arts and crafts schools). It is unanimously accepted that the type of school can strengthen several advantages – a certain distribution of social status, educational capital developed in the family, the attitude and involvement of teachers, etc.

At the same time, students from disadvantaged categories benefit if they are enrolled in classes with a large share of students from families with high educational capital. Participation in extracurricular activities, satisfaction with school, higher educational aspirations are class-wide characteristics that positively influence the school results of each individual [16], [17]. Coleman [3] explains the positive impact of the share of white students as “the middle-class entourage” effect. Besides that, the study demonstrates that students with good results and high motivation help to create a “culture of success” in the school, while students with modest results and unmotivated disrupt this atmosphere conducive to achieving school performance. As early as 1966, Coleman, in the famous study Equality of educational opportunity, stated: “the social composition of the student group is more strongly related to results, independent of the social origin of the student himself, than any other school factor” [4]. More than 30 years later, the PISA 2000 study produced the same result: “school status, measured by the average level of parents' professions, wealth and “cultural capital” has a major impact on individual performance at the international level - an even greater impact greater than the effect of the characteristics that describe the environment of origin at the individual level, in many countries” [8], [9], [18].

Since Romania has a strongly differentiated educational system at the high school level and there are significant differences between schools (and even between classes within the same school, depending on the specialization), educational mobility is determined by the desire to control the type of school attended , the composition of the group of students, the relationships between them, their families and the teaching staff, teaching-learning and evaluation methods, etc. There are classes with a large share of students from highly educated families, where an educational climate is crystallized and has created conditions for academic performance, a culture of school success that leads to good results by meeting the perseverance of pupils and parents with the positive expectations of teachers [10], [16]. Catalin Zamfir, in his 2005 study on poverty and the risks in the development of children in Romania, shows that there is a marked tendency of educational polarization and inequality of opportunities between children who complete only the compulsory level of education, with less prospects for socio-professional integration, and those completing all levels of education [34]. Moreover, the highest values of school dropout are also recorded at this stage, at the transition from the secondary to the high school (upper secondary) cycle [23], [24]. School dropout outlines negative personal developments, determining the reduction of the range of the professional opportunities for young adults [21], [22]. The measures that want to be effective must aim not only at developing the educational infrastructure, increasing the quality of education offered by the school or increasing financial transfers from the state budget and/or local budgets to children in difficulty and their families, but also at changing attitudes, the behaviors of the population towards education. [27], [28].

DATA AND METHODS

In order to analyze the mobility of the flows of pupils admitted to high school in 2022, we created a database taking the raw information from two government sources: the official website of the Ministry of Education, the section of admission to high school, and the database of graduates from the National Assessment Exam 2022, of candidates from the North-East Region and of the candidates from all other counties of the country who have been admitted to continue their studies at a high school in this region. Thus, in the 6 counties of the region, 20430 students were admitted, 52 of them coming from other regions; at the same time, 147 secondary school graduates chose high schools in localities outside the North-East Region and they are not included in the analysis.

The quantitative flows of the student population include the main educational indicators: the environment (urban/rural) of the school of origin and the high school of destination, the profile and specialization. With the establishment of the volume of relations between the localities of origin and the high school centers, of the types commune[6] to commune with high school, commune to city, city to city, city to commune with high school, it was necessary to create a database that included all the geographical coordinates of the LAUs that have secondary schools and high schools: of the 552 administrative units, only the schools in two communes in Bacău county, totaling 31 students, did not have any single student admitted to high school. ArcGis Pro software was used for the cartographic representation of student flows (fig.4). We used a multicolored flow structure in order to highlight the attractiveness of school centers of regional importance and to facilitate the research of intra-county educational mobility, the nuances representing high school destinations, and the circles – the number of students admitted in the same locality where they graduated from the secondary school.

In addition to this database, the second part of the study includes a detailed analysis of the determining factors in maintaining the limits of the educational attractiveness potential. According to the same data sources, for the Ascending Hierarchical Classification (AHC), using the PhilCarto software (fig. 5), we considered 5 indicators that derive from the first part of the study, for each pupil (origin and geographical environment), and locality with high schools (variety of typologies and specializations), including a composite index. The values obtained were standardized by reporting them to the maximum of the string, and the profiles of the classes – relative to the regional average.

a) The number of high schools, separated according to their typology, represented in the form of a composite index (fig. 2);

b) The share of students coming from the urban environment;

c) The share of non-native students;

d) The share of local students who stayed in the same locality where they graduated from secondary school;

e) The number of specializations offered by the high schools of each school center.

The composite index includes the classification of localities according to the complexity of the school offer of each high school center, respectively the number of high schools and their typology, ranked according to reputation, school success and general admission averages. For example, national colleges are elite schools, which record the best academic results, determining the strongest competition between pupils with the highest exam

[6] Commune, LAU or municipality – local administrative unit, composed of one or more villages

averages, both local areas and from outside of the county limits, while technological high schools , distributed mainly in rural localities and in cities with less than 20,000 inhabitants, manage to attract only students from the vicinity, most of the time with average of very poor results in the National Assessment, which leads, in the end, to a low graduation rate. Taking into account these factors, each typology is assigned an index, as follows:

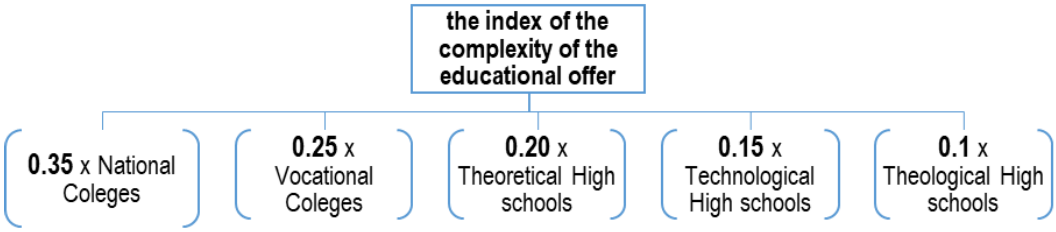

Figure 2. Calculation structure of the composite indicator of the complexity of the educational offer

RESULTS AND DISCUSSION

The school flows of high school students represent the earliest form of migration on a county and regional level. At this stage, the pupils are mature enough to take responsibility for the daily trips, in the case of commuters, as well as temporarily moving to a high school center if they come from localities that do not offer this type of educational service or their cities do not have the options and standards they target. Thus, educational mobility, due to the multitude of high school centers and the variety of school population pools, is shaped by a complex of factors, starting from the quality of the teaching act, the degree of competition in the classroom and the additional financial investments of the family during the secondary school cycle (4 years), which shape the intellectual capacities of each candidate, mathematically reflected through the admission average. Calculation formulas have fluctuated over the years, aiming to enroll as many pupils as possible in the system, including those with a pronounced school failure risk, trying to improve long-term imbalances caused by the interruption of the educational process at 8 or 10 classes (for those who enroll in professional schools, but don't pass the baccalaureate exam). In 2022, the formula applied was: the ratio of 80% × National Assessment average + 20% × the average of the V-VIII years (due to the increased amplitude of subjectivity, which is manifested by the students overevaluation by 15-20% compared to the exam results). This methodology proves to be against pupils from rural areas, besides the other challenges involved in attending high school: only 66.9% of them will continue their studies, compared to 81.4% of pupils that graduated from urban areas. In addition, of the 969 rejected pupils, 71% come from rural localities. Thus, from the stage of enrollment in the National Assessment and promotion to the admission to high school, the counties of the North-East region “lost” 7572 pupils (fig.3).

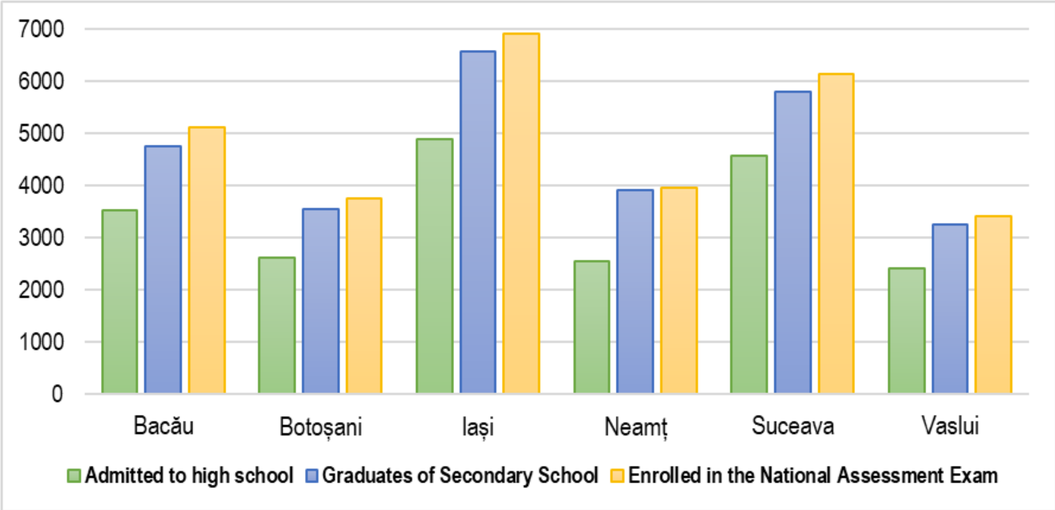

Figure 3. Distribution of the number of students from enrollment in the National Assessment, until admission to high school, by county

Once the competition average is established, the choice of high school, profile and specialization is influenced by a series of practical motivations, negotiated by financial capital (distance-time, (in)dependence on a means of transport, the possibility of obtaining a scholarship, accommodation options, the existence of public accommodation units of the high school, the capacity of the family budget to cover these expenses) and social-cultural (the high school's reputation, the typology of the pupils attending it, its geographical location in terms of ethnic landscape and security, the level of training of the teachers or the relations of kinship / friendship with other people who have connections with the institution). Thus, the selection preferences converge in the natural direction of creating the most important flows towards the largest urban centers, supporting the idea of the dependence of their attractiveness according to their demographic mass [25] and the complexity of the educational offer. Although the school population of the rural environment is roughly equal to cities ones, most relationships are urban to urban. (10,692 students), of which 93.6% stayed in the same city. Rural to urban relationships total 8562 students, representing 88.5% and create most of the migration flows in fig.4. Rural to rural ratios are limited both by the small number of places at these high schools (1-3 classes, for aproximately 50-60 pupils,) and by the extremely small polarization area of local size. In particular, 66 students from the cities chose rural high schools from satellite localities (eg: Dorohoi to Şendriceni, Roman to Horia, Broşteni to Borca). Although this type of relationship is the rarest, due to the strong attraction of the "urban" status of the high schools in the locality of origin, the main motivation is explained by the quality of the teaching act: for a student with a medium admision average, who could aspire to a low-rated major from a technological high school with questionable reputation and results, it is a better choice to go to a theoretical high school in the suburbs, where he will have less competition and a superior academic training than the previous option [6], [19].

In terms of territorial coverage with high school educational services, the county seats cities consolidate the largest polarization areas, while the catchment area of the other urban centres is limited to a local level, (with the exception of Câmpulung Moldovenesc city, where the only military high school in the whole region is located). In general, the densest flows develop within short distances from the high school centre. In the case of cities of higher administrative rank, due to the diverse school offer, they manage to create flows from distant areas, going beyond the county boundaries. The mapping of multipolarised flows with separate shades highlights intercounty migration, characteristic of communes at administrative boundaries, where it is more convenient, in terms of distance, a high school from a modest school centre in the neighbouring county (Siret, Negrești, Roman). There are also a lot of rural areas with poor accessibility to educational services in units that are not found locally (at least one technological high school): the north-west of Suceava county, eastern part of Botoșani county. These restrictions, caused by the peculiarities of the relief or/ and the underdeveloped road infrastructure, negatively influence the educational and economic integration of the young population and act in the sense of their social isolation [25], [32]. At the regional level, each high school center competes to capture as gymnasium pupilss as possible and to expand its local polarisation capacities:

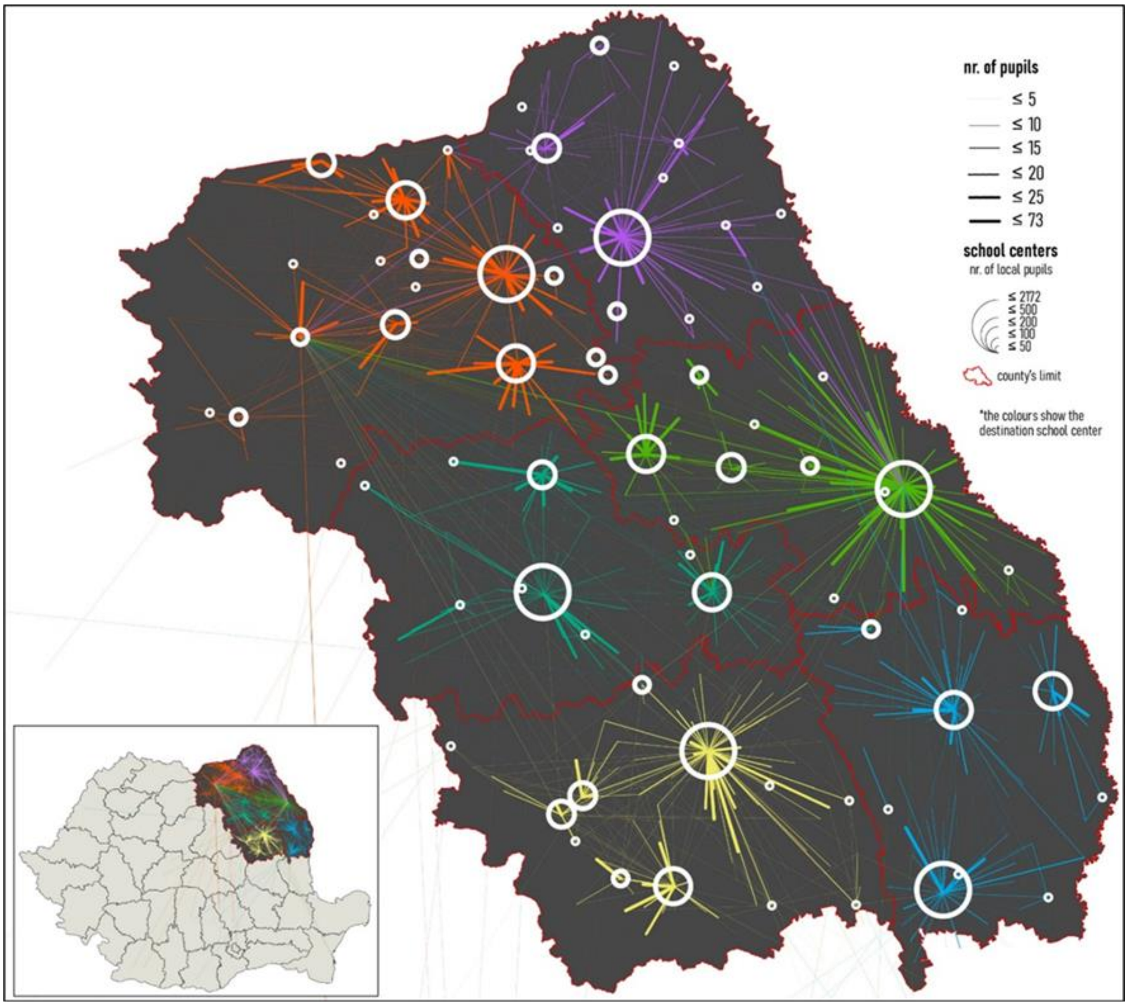

Figure 4. The flows of students enrolled in high school in 2022

Iași: at regional level, Iași stands out as the largest educational and cultural centre, which manages to attract students from all 5 neighbouring counties and dominates the intensity of flows from the entire county, being the only alternative even for students located more than 60 km away, in the southern parte of Botoșani county. In fact, in Iași county the most important high school centres are located Iași and Pașcani city, which polarise the north-western communes. Pupils in the north-east and south-east have fewer options, represented by rural high schools with a small number of places and majors (Belcești, Răducăneni, Țibănești, Vlădeni).

Botoșani: the county seat has the largest catchment area, but the multitude of secondary schools balances the length of the flows: the towns of Dorohoi, Săveni and Darabani, with average capacities to absorb the school population, take advantage of their peripheral position, draining the majority of pupils from the local area without competing with each other.

Vaslui: has the most christallerian geometric distribution of high school centres, with three main actors: Vaslui, Bârlad and Huși, which have developed their school flows over medium distances, due to the intersection of catchment areas. The other localities with high schools are unattractive even for their own students, the polarisation capacities are low and oscillating [25].

Bacău: benefits from a democratic distribution of high school centres, the most important urban poles are Bacău, Onești, Moinești and Comănești, which have retained their catchment areas from areas for which they are the most suitable high school option. The location of the other small and rural urban centres is the only resort for educationally isolated areas.

Neamț: as in the previous counties, the three main urban centres (Piatra-Neamț, Târgu Neamț and Roman) ensure accessibility to the eastern area of the county, and for pupils in the sparsely populated mountainous west the most viable options are Bicaz and Borca.

Suceava: is the county with the densest urban network, therefore the flows have developed over short distances. Even small towns (Siret, Vicovu de Sus) manage to consolidate their own polarisation area without interfering with larger centres. Rural high schools, although with a modest variety of specialisations, are numerous and balance educational accessibility.

The second part of the study aims to classify the localities according to the above mentioned values:

- Complexity of the school offer: high schools with a diverse school offer compete for the best pupils and attract the most numerous and distant flows;
- Share of pupils from urban areas: the high share of pupils from urban areas generally increases competition due to higher averages;
- Share of local pupils who chosed the high schools in the same city/commune: high school centers with a high share of secondary school graduates who have stayed in the same locality are the most attractive at county level; a pupil from Iași would have few reasons to leave for another high school in another city (except for circumstantial reasons such as family migration);
- The proportion of pupils who are non-local: a key element in defining the county and regional hierarchy. The high proportion of pupils from other localities reflects a wide area of polarisation;
- Number of majors (specialisations): determines the level of competition for the best high schools, and those with rare majors (military, railway) favour them regionally.

The application of the AHC method and the ranking of centres in 5 classes was considered the most appropriate to reveal educational differences conditioned by administrative rank, geographical position, population density and territorial competition (fig. 5). Thus, the 5 classes are differentiated as follows:

Class I: complex school centres with wide polarisation areas, due to the variety of elite educational units and numerous specialisations;

Class II: mainly rural secondary schools and small towns with rural characteristics, with elementary specialisations, with few pupils, attracted from the immediate vicinity;
Class III: small rural and urban high schools with simplistic high school provision, located near to the large centres, which attract their pupils but provide a local alternative for those with poor backgrounds from nearby localities.

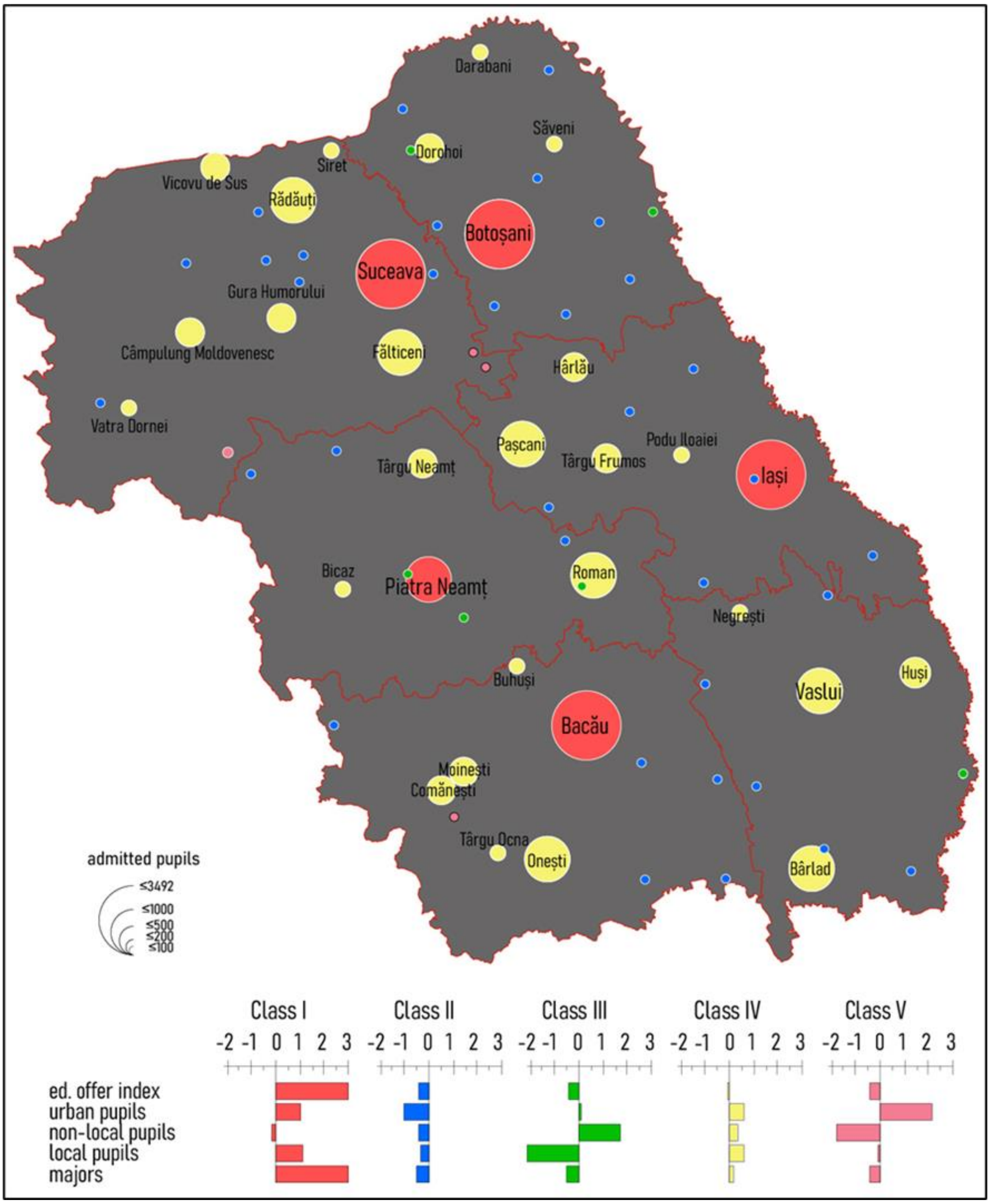

Figure 5. The Ascending Hierarchical Classification of high school centers in the Northeast Region

Class IV: school centres of county importance, with more modest offers in relation to county seats, but varied in relation to small towns (except Vaslui municipality, which is a country seat, but does not act like one, in terms of complexity of the educational provision), and with zonal polarisation areas;

Class V: local urban high schools, with insignificant polarisation areas, attractive only to local students.

Class I groups the largest cities in the region, with higher rank in the county administrative structure, 3 of them (Iasi, Suceava and Bacau) are also university centers, a parameter that strengthens their superior position both in terms of the volume of student flows, catchment areas existing throughout the county, and the pressure on the number of places, due to both the high population density of the cities and the flows from the peri-urban area, which determines the general increase in the last admission average. In general, most of the pupilss with the highest averages (above 9.00) from towns over 30 km choose county seats, even if they have at least one centre with similar quality educational services nearby. Of this class, the length of the flows is reduced only in the case of the cities of Suceava and Piatra-Neamț, due to the urban alternatives in the vicinity, with a long educational tradition and renowned institutions (Rădăuți, Roman).

Class II combines rural high schools and a number of small towns with similar educational characteristics (Flămânzi, Solca, Murgeni), with only one technological high school, where more than 70% of students come from rural areas. These localities with high schools are not attractive either for those from other localities or for local pupils with higher academic results, who prefer reputable alternatives, although they involve higher costs. However, they are of vital importance in the territory as they are located in areas of a deep rural character, with low-income population, facing poor road infrastructure, inhibiting the overall moral development, factors reflected in the lower percentages of people with middle or higher education levels [11], [20]. These technological high schools address to pupils with a high risk of dropping out, offering them accessible specialisations with which they could quickly earn an income: agriculture, mechanics, tourism and catering.

Class III includes localities with only one secondary school, either technological or theoretical, with more than 90% of pupils coming from rural areas, from nearby localities and represent a good alternative to relieve the pressure from the large centres near which they are located (Horia, Roznov, Șendriceni). They essentially concentrate pupils from other localities as they are not on the list of preferences for local pupils, who opt for the higher administrative options, which are in the imediate vicinity.

Class IV is represented by the majority of medium-sized cities, with secondary or tertiary administrative rank, they have created a constant catchment area, managing to establish themselves as educational centres with local polarisation. In most cases they intersect their polarisation areas (Vaslui vs. Bârlad, Gura Humorului vs. Câmpulung Moldovenesc or Pașcani vs. Târgu Frumos). The centres that have peripheral positions in relation to the county seats and are the only centres with a "quality" reputation in relation to the rural alternatives maximise their potential for attraction through local monopolisation, extending their area of influence (Roman, Vatra Dornei, Darabani, Negrești) [15].

Class V is represented by only 4 urban high schools: Dărmănești, Dolhasca, Liteni and Broșteni, small localities, located in the shadow cone of large cities or in a sparsely populated and demographically ageing area, respectively with a low potential of school emissivity (Broșteni). This category of centres manages to keep most of its local pupils, but is unable to attract those from nearby localities as they have a rural type of school offer, with elementary specialisations, which does not stimulate competition between pupils, and the better alternatives are nearby.

CONCLUSIONS

This study demonstrates the importance of physical-geographical location in relation to educational centres as a defining factor for socio-economic success in adulthood. The transition from 8th grade to high school is certainly the most critical transition stage, which needs to be considered responsibly. The Northeast region, with the largest school population compared to other regions, has a dense network of high school centers, with few areas that remain outside of school polarization areas. Many medium-sized towns are the legacy of forced urbanisation during the communist period, which lost their demographic momentum after 1990 due to migration and an ageing population. For them, attracting young high school graduates is essential for urban revitalisation and securing economic strength. Inevitably, both these and rural high schools, as well as towns with the same educational offer as a commune, will compete for pupils with county centres, which, thanks to their superior polarisation capacities and prestigious institutions, will always be the resorts that will 'draw away' local elites. Naturally, locally polarised and proximity-based high schools are the best alternative both for low-performing students in rural areas isolated in terms of infrastructure and for those who could not afford the cost of migrating to a higher educational centre. These are the cheapest mechanisms for the state to keep them in the education system, providing them with vocational qualifications that can facilitate their integration into the labour market. Although it is morally wrong, educational equity can be ensured by the state in terms of improving territorial inequalities in terms of quality (access to high schools renowned for the performance of pupils and teachers), by developing the infrastructure for access to high school services, but this does not exclude substantial financial efforts that affect the most vulnerable social groups, calling into question the free status of education..

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THE ROLE AND IMPORTANCE OF THE STATE FOR THE SOCIAL TOURISM DEVELOPMENT: A CASE STUDY OF SERBIA

DOI: https://doi.org/10.18509/GBP23137g
UDC: 338.48-2-058.34:347.748(497.11)

Vuk Garača
Svetlana Vukosav
Milan Bradić
Jelena Tepavčević
University of Novi Sad, Faculty of Science, Department of Geography, Tourism and Hotel Management, **Serbia**

ABSTRACT

In every society there are sensitive social communities, which the state recognizes and in various ways stimulates their inclusion in social life. One of the ways of including such layers of society in social flows is social tourism. The methods of such stimulation differ from historical time and from each country. They generally come down to the existence of specialized closed or semi-closed hospitality establishments, whose activities and work are co-financed by the state or society. Vouchers are another, modern form of social and state assistance for the sensitive categories of the population inclusion in tourism. It is a direct form of giving to each individual, who meets certain criteria to choose the place and time of it's realization. The aim of the paper is to show the Republic Serbia Goverment's role in the development of social tourism and its importance for the overall tourism development of the country. Using the method of correlative analysis, certain significances of the state vouchers's use were determined for domestic tourism in Serbia during the period from 2015 to 2022..

Keywords: social tourism, state, vouchers, Republic of Serbia

INTRODUCTION

The benefits of tourism as an economic activity can be very broad, referring to benefits for the economy, social life for people living in destinations, as well as personal benefits for tourists [1]; [2]. These personal benefits were found to include: rest and recovery from work; provision of new experiences leading to broadening of horizons and opportunities for learning and intercultural communication; promotion of peace and understanding; personal and social development; visiting friends and relatives; religious pilgrimage and health; and subjective well-being [3]; [4]; [5]. However, all these important advantages and benefits of tourism, which refer to the individual as a member of the wider social community, are not used by everyone, especially those who do not have enough financial resources to travel and/or those who are unable to do so for health reasons. Therefore, social tourism is emerging, which should enable the inclusion of all members of society in tourism. Such participation is made possible through the provision of some form of social support system [6]. Social tourism refers to: all activities and phenomena in the field of tourism that result from the inclusion of otherwise vulnerable and excluded groups in participation in tourism. "The inclusion of these groups in tourism is made possible by financial or other interventions of a well-defined and social nature" [7]. Social tourism is an area in which those who are at risk of poverty could get the opportunity to vacation at affordable prices or such prices, the amount of which is subsidized by the state/society. Defined as „tourism with added moral value, the primary objective of which is to benefit either the host or the visitor in the tourism exchange“ [6] social tourism provides tourism opportunities for those who would otherwise not be able to participate due to certain disadvantages, such as lack of money, their a full-time carer role or a health problem or disability. Social tourism includes a range of activities and programs across Europe and elsewhere that provide social and economic benefits, stimulate tourism development or promote understanding between guests and hosts in tourist destinations [7]; [8]; [9]; [6]. But neither the general public nor potential recipients are usually aware of such a possibility [10].

In recent years, there has been a resurgence of research on social justice and welfare issues in tourism [11]; [12]; [13]. including the concept of social tourism. Haulot [14] defines social tourism as „the totality of relations and phenomena arising from the participation of those social groups with modest incomes - participation that is enabled or facilitated by measures of a well-defined social character“. Although there are different interpretations of what constitutes social tourism and how it can be implemented, Minnaert et al. [15] distinguish forms of social tourism related to visitors and hosts. Social visitor-related tourism includes measures to combat social exclusion through support programs for low-income and other excluded groups. The main underlying justification for social tourism initiatives aimed at visitors is the fight against social exclusion and that these types of interventions require a special ethical orientation either at the level of government or society. Host-related forms of social tourism are more easily reconciled within ethical issues because they focus on redistributive practices between host and guest communities. Richards [16] argues that there are many culturally specific and historical factors that shape the structures and policies of the welfare state and their orientation towards tourism promotion more for „beneficial economic externalities than for the health and social benefits that justified the extension of holiday rights in the past“. This is likely to create more variation in how social tourism is understood as a social policy problem depending on the national context [17].

The origin of social tourism lies in the idea that tourism provides positive and important recuperative and educational benefits for ordinary people, and that such opportunities should be extended to all people in society. However, Tourism has become an industrialized system, an important pillar of the European economy, and therefore the basis for the participation of tourism has been fundamentally reconfigured [18] and is increasingly becoming a luxury and unaffordable need for a large number of people. In addition, since the global financial crisis, which began in 2007, there has been a further process of economic restructuring across Europe with high levels of unemployment, growing inequalities in the distribution of income/wealth and severe pressure on health and social care systems [18], therefore , general long-term economic growth and development has not trickled down to all members of society, which is why an increasing number of poorer members of society will feel excluded from travel and leisure opportunities as people did almost a century ago [19]. At the same time, many Europeans now consider the right to travel and tourism a social right [20], so many Europeans have recognized the important restorative function that tourism has for workers and reinforced the idea that there is a social right to travel and rest from work, making provisions that allow the majority of their population to enjoy access to leisure [21]. However, these interventions should have a well-defined social purpose, such as combating isolation and loneliness in older people, or encouraging family cohesion among low-income families, or supporting accessible tourism for people with disabilities. Although social tourism is not a new concept and represents an important pillar of the European tourism system, there is still a widespread lack of awareness about the practices, policies and activities that make up this phenomenon [19], it has attracted more attention from researchers in recent years [22].

Recognizing the economic importance of social tourism, many governments have begun to promote access to leisure travel as a positive social and economic activity. However, government provisions that ensure equality of access to tourism are not universal and range from tacit support to direct investment in providing services in the form of social tourism [23]. In this sense, an increased concentration of those travelers who belong to the category of social tourists has been observed, in the off-season [10], as is the case in Spain, where the "IMSERSO" program offers vacations for senior citizens (and companions) in domestic seaside resorts on the coast , which involved 10.5 million people, providing year-round employment for tourism workers and income, generating 13,000 direct and 85,000 indirect jobs and a return of €300 million to the Spanish government [24]; [25]. To encourage similar schemes across Europe, the European Commission launched the Calipso program in 2008, which aims to reduce seasonality by helping specifically defined social tourism groups to travel between different European countries [6]. This undoubtedly indicates that social tourism can contribute to greater sustainability of destinations, through a longer duration of the tourist season, equalizing the expansion of demand, ensuring more stable employment and increasing tax collection [26]. However, attention should be paid to the possible segregation of this already socially isolated group, as well as to the fact that these are low-paying groups, which is why low preferences for service providers may occur, often due to the cultural habits of vulnerable sections of the population, or in the case of persons with disabled for the needs of greater intensity of care for users [10].

While evidence is still emerging on the potential of social tourism to contribute to a more sustainable tourism industry [27], it is widely recognized that it has a positive psychological impact on older people, on their subjective well-being, quality of life, self-rated health and life satisfaction, without regardless of the type or duration of the trip [28]; [29]; [30]. Similarly, it plays a role in the creation and sharing of memories [31]; [32]; [33] and reminiscence is recognized as promoting and maintaining the mental well-being of older people as it involves memory and encourages social interaction [34]; [35]. Emotional and psychological well-being are vital to aging well, and while loneliness and isolation are not concomitants of aging, many older people lead rewarding and socially engaged lives [36]. Accordingly, studies of social tourism clearly demonstrate its positive impacts, particularly on families [37]; [25]. Minnaert et al. [9] argue that social tourism helps disadvantaged families to increase their family and social capital and expand their social networks and encourage positive behavior and self-esteem. Thus, tourism (read social tourism) provides opportunities for promoting social inclusion, expanding limited social domains, facilitating social interaction and networking, and “for reaffirming oneself and developing a new identity in later years” [38]. Studies show that tourism (read social tourism) has a positive impact on a number of economically or otherwise disadvantaged groups, including low-income families, teenage mothers, and people with health problems and disabilities and their caregivers [39].

In Europe, there are clear differences between the northern (e.g. Great Britain, Germany, Scandinavia) and the Mediterranean (e.g. France, Spain) models of social tourism, where the former is dominated by charitable organizations, and the latter is the intervention of social services, trade unions, etc. [40]; [41]. Many European social tourism schemes are based on „inclusion“ and „stimulation“ models of social tourism that encourage participation for all [6]. In today’s times of austerity, many governments have re-evaluated their social protection programs and the potential economic benefits of social tourism have received an increased level of attention [39], but it should be borne in mind that many European countries have a firmly defined structure of social tourism, in which way they encourage their own economy and positively affect the socioeconomic status of users of its services. Among them are some of the leading European economies: Belgium, France, Germany, Poland, Great Britain, Spain, but also one Romania [42]. In addition, five European countries: France, Hungary, Italy, Romania and Switzerland, promote social tourism using a voucher scheme. The systems are quite similar and only apply to domestic tourism. There is a wide application of vouchers that varies from country to country: payment for travel, accommodation, tolls, activities or other benefits depends on the maturity and reach of the voucher program [43].

SOCIAL TOURISM IN THE REPUBLIC OF SERBIA

Recognizing the importance of tourism as an economic activity and the possibility of stimulating domestic tourism through support for disadvantaged population groups, the Government of the Republic of Serbia started issuing vacation vouchers in 2015 and thus began to develop one of the forms of social tourism. In June 2015, the Government of the Republic of Serbia decided to further encourage domestic tourism through the scheme of awarding vacation vouchers for subsidized accommodation services of a minimum of five nights in Serbia, outside the place of residence of the voucher beneficiary. Accommodation services are provided by business entities and other legal entities. This includes institutions for medical rehabilitation (special hospitals in the spas of Serbia) that provide prevention, treatment and rehabilitation services. Also, there are natural persons who provide accommodation services in categorized domestic and rural tourist households, where catering activities are carried out in accordance with the Law on Tourism. The value of the voucher is 5,000 dinars (approx. 42 EUR) and that is the maximum amount that the user can use once a year, regardless of the value of the accommodation service, except in 2021, when the value of the voucher is increased to 15,000 dinars (approx. 125 EUR). The list of accommodation service providers is updated weekly and published on the website of the competent ministry. The number of voucher applications is limited by available budget funds. Vouchers can be used in the territory of the Republic of Serbia, excluding the territory of Belgrade, Novi Sad, Niš and Kragujevac (because it is estimated that these cities achieve an increase in tourist traffic without incentives). Vacation vouchers can be used by: 1. pensioners; 2. unemployed persons on the records of the National Employment Service and other persons on the records of the National Employment Service (beneficiaries of special benefits and temporary benefits); 3. beneficiaries of allowance for assistance and care of another person, who are entitled to that right in accordance with the law governing social protection of citizens; 4. Beneficiaries of the right to an allowance for assistance and care of another person, who exercise that right in accordance with the law regulating pension and disability insurance; 5. employees with a monthly income of up to RSD 60,000 (about EUR 488); 6. disabled war veterans and civilian disabled veterans with a monthly income of up to 60,000 dinars (about 488 euros); 7. Family pension holders in case of death of a soldier; 8. owners of rural households, registered in the Register in accordance with the Law on Agriculture and Rural Affairs [43].

This practice continued continuously until 2022, with a constant increase in the amount and number of vouchers, which are determined to be issued, which proved to be beneficial to the domestic tourism economy, the increased number of domestic tourists and overnight stays, and the increased revenue of local self-governments from collection. tourist tax and the state budget from the collection of VAT. The subject of this paper is the role and importance of the state for the development of social tourism, through a case study on the example of the Republic of Serbia. The aim of the paper is to show the role of the Government of the Republic of Serbia in the development of social tourism and its importance for the overall tourism development of the country.

METHODOLOGY

During the research process, several different methods were used: research of primary and secondary materials, statistical method, but also synthetic, comparative, critical and descriptive method.

Research at the table implies the study of primary and secondary material [44]. This method was used to obtain statistical data on tourist traffic and the number of overnight stays in Serbia in the period from 2010-2022. year, obtained using the official publications of the Statistical Office of the Republic of Serbia, as well as data on the number of issued vacation vouchers, their value and the number of nights spent using vacation vouchers in the period from 2015-2022. year, at the personal request of the Ministry of Tourism. At the same time, domestic and foreign literature in the field dealt with in this paper was reviewed.

Statistical data collected in the first phase, the so-called research at the table, were processed using different statistical methods. First of all, it is a method of correlation analysis, which is used to investigate the strength, that is, the intensity of the quantitative agreement of observed phenomena. In other words, correlation represents the connection of observed phenomena, where the existence of the influence of one phenomenon on another is examined, that is, the influence of an independent function on a dependent function. The indicators of linear or Person's correlation are: coefficient of determination, coefficient of indeterminacy and coefficient of linear correlation, and for the purposes of this paper, the last one will be used [45].

The linear correlation coefficient ($r_{1,2}$) shows the strength, that is, the intensity of the linear correlation between the variables X_1 and X_2, where:

$$r_{12} = \pm\sqrt{r_{1,2}^2}$$

The value of this coefficient is in the interval $-1 \leq r_{1,2} \leq 1$, when there is a statistical correlation between the observed phenomena. If r1,2=0 between the variables X_1 and X_2 there is no connection, while in the other case, when $r_{1,2}=\pm 1$ there is a connection and it is functional. In statistical theory and practice, there are several degrees of correlation strength:

if $0{,}0 \leq |r_{1,2}| \leq 0{,}5$, the correlation relationship is weak,
if $0{,}5 \leq |r_{1,2}| \leq 0{,}7$, the correlation relationship is significant,
if $0{,}7 \leq |r_{1,2}| \leq 0{,}9$, the correlation relationship is strong,
if $0{,}9 \leq |r_{1,2}| \leq 1{,}0$, the correlation relationship is very strong.

In this case, the number of vacation vouchers issued, their value and the number of nights spent using vacation vouchers were observed, as an independent function of X_1 and the number of nights (domestic and total) and tourists (domestic and total) realized in the Republic of Serbia in the period from 2015-2022 year, since the action of issuing vacation vouchers, as a form of social tourism, as a dependent function of X_2.

RESULTS

In the phase of research at the table, during the collection of primary and secondary material, statistical data on tourist traffic in the Republic of Serbia for the multi-year period from 2010-2022 was obtained. year, on the basis of which statistical series of data were formed, which will be used in the next phase of the research, i.e. methodological data processing to be used (Table 1.) [47].

Table 1. Tourist traffic in the Republic of Serbia in the period from 2010-2022

	Year	Domestic overnight stays	Total overnights stays	Domestic tourists arrivals	Total tourist arrivals
	2010.	4.961.359	6.413.515	1.317.916	2.000.597
	2011.	5.001.684	6.644.738	1.304.443	2.068.610
	2012.	4.688.485	6.484.702	1.269.676	2.079.643
	2013.	4.579.067	6.567.460	1.270.667	2.192.435
The lowest values of domestic tourism in the given sequence	2014.	3.925.221	6.086.275	1.163.536	2.192.268
	2015.	4.242.172	6.651.852	1.304.944	2.437.165
	2016.	4.794.741	7.533.739	1.472.165	2.753.591
	2017.	5.150.017	8.325.144	1.588.693	3.085.866
	2018.	5.678.235	9.336.103	1.720.008	3.430.522
	2019.	6.062.921	10.073.299	1.843.432	3.689.983
	2020.	4.936.732	6.201.290	1.374.310	1.820.021
	2021.	5.732.833	8.162.430	1.720.054	2.591.293
The highest values of domestic and tourism in the given sequence	2022.	7.306.219	12.245.613	2.096.472	3.869.235

Source: Statistical Yearbook of Serbia (2011-2023), Statistical Office of the republic of Serbia

By observing and analyzing the data in Table 1. it can be observed that in the five-year period from 2010-2014. domestic tourism is continuously decreasing, namely the number of domestic overnight stays by 20,1% and the number of domestic tourist arrivals by 11,7%. This was largely due to the drop in citizens' standards and the increase in the price of tourist services. On the other hand, tourist traffic from abroad varied, so in the same period the total number of overnight stays increased to approximately the same level, except for 2014, when, compared to the previous year, it decreased by 7,3%, while the total number of tourist arrivals increased by 9,6%. This could be explained by the fact that the number of tourists grew (read foreign ones), while their average length of stay fell, so in that sense the total number of overnight stays decreased by the aforementioned 7,3%. In the period from the beginning of the application of vacation vouchers as a Blade measure of the Republic of Serbia to support domestic tourism, from 2015-2022. the continuous growth of domestic tourist traffic is evident, namely the number of domestic overnight stays by 86% and the number of domestic tourists by 80%, while in the same period the number of foreign tourists also increased significantly, which is reflected in the significant increase in the total number of overnight stays by 101,2% and total values of the number of tourist arrivals by 76,5%.

As the reason for the increase in domestic tourism demand, the Government of the Republic of Serbia cites the implementation of the measure of issuing vacation vouchers, which in 2015 appeared as a modest measure worth almost EUR 600.000, when just over 14.000 vouchers were distributed and about 155.000 overnight stays were registered on that basis.

Table 2. Issued vouchers, values and overnight stays for 2015-2022

Year	Vacation vouchers	Overnight stays based on vouchers	Voucher values (ЕУР)
2015.	14.087	154.325	596.907
2016.	46.000	342.700	1.949.153
2017.	91.078	626.133	3.859.237
2018.	99.076	559.186	4.198.136
2019.	119.025	652.552	5.043.432
2020.	272.856	1.235.104	11.561.695
2021.	148.850	742.660	6.307.203
2022.	354.623	2.224.373	34.220.169

Source: Ministry of Trade, Tourism and Telecommunications.

This measure became very significant in 2022, reaching a value of EUR 34.220.169, which was realized through 353.623 vouchers and on the basis of which 2.224.373 nights of domestic citizens were realized in the territory of the Republic of Serbia. If we take into account the data of 7,3 million overnight stays by domestic citizens in 2022 and 2,2 million overnight stays by domestic citizens achieved through the measure of vacation vouchers, it will be clear that the entire 30,4% of overnight stays by domestic citizens in the Republic of Serbia was financed by the Government (Table 2.) [48]. It should also be noted that this measure of the Government of the Republic of Serbia has continuously grown in all segments, except in the first year after the COVID-19 crisis, when due to reduced economic growth in 2021 there was a reduction in budget allocations according to this principle by as much as 54,6 %, compared to the previous year.

Table 3. Correlated values and coefficients for the period from 2015-2022

No.	Correlation X_1/X_2	Correlation coefficient ($r_{1,2}$)
1.	Vacation vouchers/Domestic tourists arrivals	0,645*
2.	Vacation vouchers/Total tourist arrivals	0,278
3.	Vacation vouchers/Domestic overnight stays	0,765**
4.	Vacation vouchers/Total overnights stays	0,566*
5.	Voucher values/Domestic tourists arrivals	0,701**
6.	Voucher values/Total tourist arrivals	0,455
7.	Voucher values/Domestic overnight stays	0,802**
8.	Voucher values/Total overnights stays	0,712**
9.	Overnight stays based on vouchers/Domestic tourists arrivals	0,634*
10.	Overnight stays based on vouchers/Total tourist arrivals	0,359
11.	Overnight stays based on vouchers/Domestic overnight stays	0,731**
12.	Overnight stays based on vouchers/Total overnights stays	0,613*

* Relationship is significant;** Relationship is strong;*** Relationship is very strong
Source: Own research.

Taking these data into account, there is no doubt that the measure of vacation vouchers significantly contributed to the growth and strengthening of the domestic tourism economy, but this should be brought into a statistical relationship and explained by the existence of a clear and unambiguous correlation, as evidenced by the following table (Table 3.) [49].

Based on the calculations shown in Table 3. it can be clearly concluded that there is a clear and strong connection between the Government's measures to domestic tourism support through the distribution of vacation vouchers to vulnerable groups of the population and the realized tourist traffic in the mentioned period. It has already been said that around 30% of domestic citizens' overnight stays are subsidized by the state in 2022, which is a clear indicator of the influence of the Government's policy towards tourism through social tourism support. Seen in time series from 2015-2022. year, the strength of that influence can be described as strong when domestic tourist traffic is questionable, which means that the correlation coefficient was $0.7 \leq r_{1 \cdot 2} \leq 0.9$. Thus, the number of issued vacation vouchers had a strong influence on the number of domestic overnight stays ($r_{1 \cdot 2}=0.765$), the value of issued vacation vouchers had a strong influence on the number of domestic overnight stays and showed the highest value of the correlation coefficient ($r_{1 \cdot 2}=0.802$). Also, the number of overnight stays based on vacation vouchers had a very clear and logical impact on the number of domestic overnight stays ($r_{1.2}=0.731$). A somewhat smaller connection (correlation: No. 4; No. 8 and No. 12) or a significantly smaller connection (correlation: No. 2; No. 6 and No. 10) was achieved in the relations in which the values of total tourist traffic are found (total tourist arrivals and total tourist overnight stays), because the Government's support measure was not intended for foreign tourists, who are in large numbers in the total values. However, the quality and strength of the relationship between the total value of vacation vouchers and the total number of overnight stays in the Republic of Serbia in the period from 2015-2022 ($r_{1 \cdot 2}=0.712$) can be distinguished, which clearly indicates an increase in the number of domestic tourists in total and the amount of money with which the Government of the Republic of Serbia financed the policy of social tourism, better known as „tourism for al“, wanting to help the domestic tourism economy in the crisis years in the process of development both during and after the COVID-19 pandemic.

CONCLUSION

Social tourism remains an important area for future research and policy. Increasing inequality in wealth and income, even in wealthier countries [46], means that access to tourism is becoming increasingly concentrated among the precarious in an era of systematic cuts in public sector funding. Further research is needed to provide evidence of the effects of exclusion on people, such as the effects of extended periods without access to holiday time away from home, research into the impact of breaks on emerging disadvantaged groups (such as new economic migrants, trans inebinary and intersex people). Research is needed on programs and policies for social tourism, how they can be expanded and the effects on destination sustainability. We need a better understanding of the health effects of tourism, both positive (relaxation, pleasure, learning, physical activity, relationships) and negative (breakdown of relationships, overindulgence, stress). We need to conduct interdisciplinary research with doctors, sociologists, gerontologists, social policy research and education to develop better measures and indicators of the effects of tourism, to ensure that social tourism programs lead to optimal outcomes for those most in need of support. Future research must assess the needs of people in developing countries, whose appetites for tourism opportunities and cultural and social norms are diverse, to ensure that social tourism policies and programs are relevant to their needs and create the greatest benefit [22].

Furthermore, the indirect effects of the vacation voucher scheme in Serbia are very strong and clear and can be described as follows: 1. Positive promotional results in the country through better recognition and increased awareness of Serbia’s tourist offer; 2. Mobilization of domestic tourism actors, especially in new destinations, which are often in underdeveloped regions of the country; 3. Better positioning of tourism in the economic policy agenda of the Government of the Republic of Serbia, and even 4. Setting a model for other countries in the region. The joint efforts of the promotional campaign of the Tourism Organization of Serbia „My Serbia“ and the ministry in charge of tourism helped to reverse the trend of falling domestic arrivals [43].
The Government of the Republic of Serbia has a clear vision of the development of tourism in Serbia, among other things, through the support of a wide spectrum of sensitive social groups. Therefore, it can be said that the policy of providing vacation vouchers, as a form of social tourism, has a positive and visible effect on domestic tourism and should be continued in that or a very similar way in the future.

Acknowledgments
This research is financed by The Provincial Secretariat for Higher Education and Scientific Research of Vojvodina (project No 142-451-2207/2022-01 The role and importance of social tourism in the context of the development of sustainable tourism in Vojvodina).

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CHARACTERISTICS OF CONTEMPORARY COMBAT OPERATIONS IN URBAN AREAS

DOI: https://doi.org/10.18509/GBP23149zh
UDC: 911.374.6:711.4]:355.4

Vinko Žnidaršič[1]
Aleksandar Petrovski[2]
Marko Radovanović[3]
[1]Military Academy University of Defence in Belgrade, **Serbia**
[2]Military academy “General Mihailo Apostolski”, Skopje, **North Macedonia**
[3]Military Academy University of Defence in Belgrade, **Serbia**

ABSTRACT

The general trend of urbanization at the end of the 20th and the beginning of the 21st century coincides with an increase in armed conflicts between military formations in urban areas.

Weaker armed forces tend to draw stronger armed forces into the closed environment of urban areas to mitigate the effects of their weaknesses in human and material resources. Stronger armed forces express their desire to bypass and avoid the development of armed conflicts in urban areas. On the other hand, when the operational situation requires an armed conflict to develop inside urban areas, the stronger armed forces show a tendency to disproportionately use all their material and human superiority causing damage or destruction of facilities and infrastructure systems of urban areas, and this leads to the suffering of the civilian population. The characteristics of urban areas influence contemporary armed conflicts to manifest themselves differently compared to areas like forests, flat lands, mountains, and others.

By applying the method of analysis of the content of the document, it was established that the basic characteristics of urban areas: built objects for housing and business, communal infrastructure, and the presence of permanent residents, have an impact on the basic characteristics of armed conflicts: multidimensionality, precision, non-linearity in time and space of execution, distributed content, simultaneity in action, integration of forces, interoperability and the need to respect international humanitarian law in the use of military force.

Keywords: Urban areas, Urbanization, Infrastructure, Residents, Armed conflicts

INTRODUCTION

Armed conflicts have historically taken place around and for the Cities, but are increasingly taking place within the urban areas themselves. Contemporary combat operations, as one of the forms of armed conflict, have their own peculiarities in urban areas and therefore it is necessary to notice and single out their characteristics in order to improve their success and reduce human and material losses.

Urban areas are "a part of the territory of a municipality that has built facilities for housing and business; basic utility infrastructure and other facilities to meet the needs of residents who are permanently resident there" (Figure 1) [1].

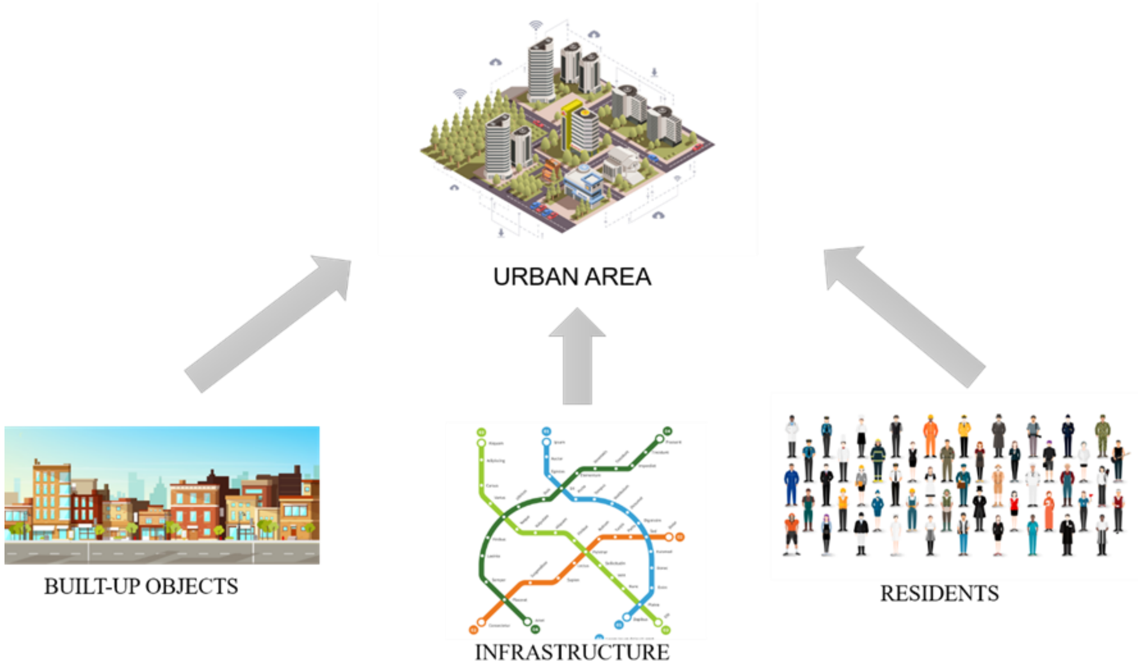

Figure 1. Elements of the urban area

Urban areas are classified according to different criteria and are most often divided into cities (urban) and villages (rural), but from the military point of view in relation to the course of operations, urban areas are a unique whole representing a special type of area that requires military units to perform actions and procedures that differ from procedures in areas of other characteristics such as plains, a mountain or a forest. For this special type of area, terms such as urban space, urban environment, urban environment, and similar are also used in the literature [2].

CONTEMPORARY COMBAT OPERATIONS

Control of political, industrial, commercial, transport, and communication centers, decisively affects the outcome of battles, campaigns, and the entire war. Technological advances, especially in aviation, have led to the fact that it is possible to conduct armed actions in a much more accurate way than in the past with significantly fewer civilian casualties and collateral damage. Urban areas are developing by number in population, size, and importance, which significantly affects the military units to impose restrictions on the conduct of combat operations [2].

Noticeable expansion reduces the space for maneuver for military units to tour them in the coming and therefore reluctantly enter conflicts within urban areas. The disadvantage of performing operations in urban areas is also influenced by the fact that two very significant, and basically opposite phenomena are happening in the world: expanded urban areas and the trend of shrinking armed forces. According to a report by the newspaper "The Economics" after the Cold War, the armies have shrunk. As an example, it is stated that western Germany, which in 1990 could engage 215 combat battalions, and in 2015, after the reunification of The German Republic, this number was 34, that is, it decreased by 84%. The number of Italian battalions [3] in the same period, dropped by 67% and the British by almost half. U.S. forces in Europe have shrunk from 99 battalions to 14, and from half a million troops to 76,000 today [4]. Such trends of shrinking armies are contrary to the expansion of urban places if it is known that it is necessary to engage many more soldiers to occupy one large populated place compared to other areas of the same size [5].

Combat operations in urban areas require more human and material resources; it is a very violent, decentralized type of armed conflict waged by relatively small units where infantry is sent to work closely with and cooperate with armored units, artillery, air forces, and all the other forces involved. urban areas represent an environment that imposes large challenges, on fast, materially equipped, and murderous military forces, relatively small, as they become larger and more complex. Historically these challenges have largely remained the same, but technological advances have led to the evolution of combat operations in urban areas [6], [7].

Contemporary combat operations are most often planned, prepared, and carried out during a state of war, in peace, and in conditions of emergency. Combat operations in urban areas are carried out as operations of preventive deployment of forces; counterterrorism operations; counterinsurgency operations; offensive; defensive and ancillary operations (Figure 2) [8]. There are other divisions of combat operations in which the basis is the use of weapons and combat to perform the assigned mission and tasks.

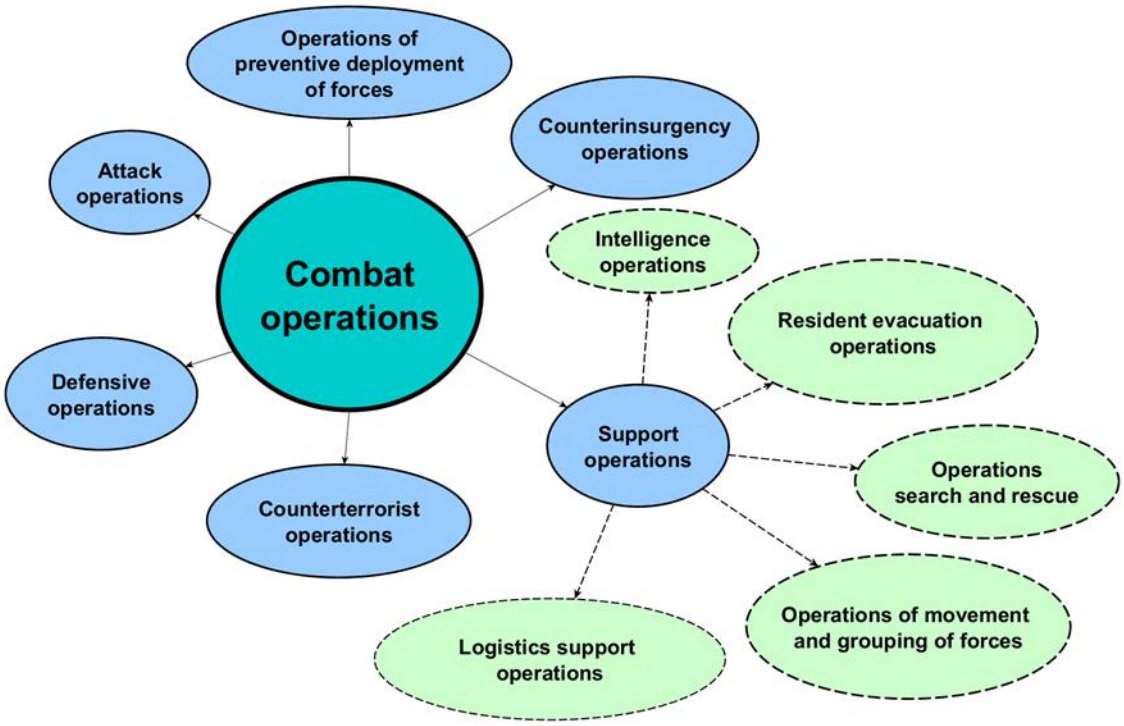

Figure 2. Classification of contemporary combat operations

The armed forces of different countries, at the beginning of World War II, had their experience in conducting combat operations in urban areas such as:

- immediate fighting on a full scale with a huge number of casualties: Stalingrad (1943), Manila (1944-1945), Seoul (1950-1951);
- aerial bombardment with a large number of casualties: Dresden (1945) and Tokyo (1945);
- Civil War: Beirut (1975-1990), Monrovia (2003);

- Revolution: Managua (), Budapest (1956);
- the precision bombing of Baghdad (2003), Belgrade (1999);
- counterterrorist operations (Marawi, 2017);
- non-combat residence evacuation operations (Monrovia (1990-1991);
- Anti-insurgency operations: Fallujah (2004 and 2016);
- Special Operations: Kyiv (2022), Mariupol (2022) [2].

CHARACTERISTICS OF COMBAT OPERATIONS IN URBAN AREAS

Urban operations are complex and challenging, they are not only purely military but also multidimensional because they need to consider the economic, social, and other characteristics of the city. Successful operations in urban areas require special tactics and training, and customized weapons and equipment. Preparations for operations in urban areas not only need to include training for combat in cities but also to better understand the "flow" of the city. Flow is the interaction of people and the exchange, of resources and information both within the city and between the city and its surroundings. This flow is similar to the nervous system of a living organism. It is also physical, i.e., connected to the existing infrastructure network of the city such as streets, canals, or railways, as well as non-physical. Functioning effectively in a populated place requires an understanding of how the city works, i.e. how all flows of information, commodities, people, energy, waste, and trade in and out of the city shape the interaction between different parts of the population with their formal and informal governance structures and actors. Some urban experts believe that the social infrastructure of the city is more important than the physical infrastructure [6],[9].

Intense combat at close distances on a wide front is a feature of large-scale combat operations during conflicts in urban areas. Armed forces need the ability to locate, closer and destroy the enemy, or repel enemy attacks in an urban setting. Armed forces contribute to teams of combined armaments that deliver combat power capabilities using unique capabilities according to the requirements and mission of the operation. Regardless of technological advances, combat forces on the ground achieve many of the joint force commander's goals using well-planned, rapid, violent action along with surprise, boldness, concentration, and pace. One cannot overestimate the need to use and use well-trained, integrated and trained teams of combined weapons. These forces must have the training, organization, weapons systems and skills to quickly and violently isolate an urban target, gain a foothold through strike action and secure it from a determined enemy, maximizing maneuver, fire support and effective small unit leadership to defeat that enemy. In limited emergency operations, effective tools and broad freedom are given to small units, ensuring huge, rapid mortality on contact that can destroy enemies in the city and, second, minimize collateral damage. Developing the ability to fight closely with the security forces of a partner country can shape the operational environment and prevent conflict [10].

By comparing the influential factors of modern combat operations in urban areas with those carried out in other areas, it is noted that although they share most of the same characteristics, there are differences in their details (Table 1) [2].

Table 1: Aspects comparison of combat operations in urban areas and in other environments [2].

Aspects	Urban areas	Plains	Forest	Mountain
Number of civilians	High	Low	Low	Low
The presence of valuable infrastructure	High	Low	Low	Low
Multidimensionality of the operating environment	Yes	No	Some	Yes
Performance restrictions	Yes	Some	Some	Some
Observation, detection, range	Short	Long	Short	Medium
Directions of movement	Many	Many	Few	Few
Freedom of movement in vehicles	Low	High	Low	Medium
The functionality of communication means	Degraded	Fully capable	Degraded	Degraded
Logistics requirements	High	High	High	Medium

The main characteristics of modern armed conflicts in urban areas are: multidimensionality, precision, nonlinearity in time and space of execution, distribution of content, simultaneity in action, integration of forces, interoperability and the need to respect international humanitarian law in the use of military force [11].

Multidimensionality

Multidimensionality implies that, in addition to the physical dimensions of the urban area (length, width, depth, and height), the political, social, economic, technological, and information dimensions must be taken into account, in which human resources imply not only military personnel but also the civilian population of the populated place in which the combat operation is carried out (Figure 3) [11].

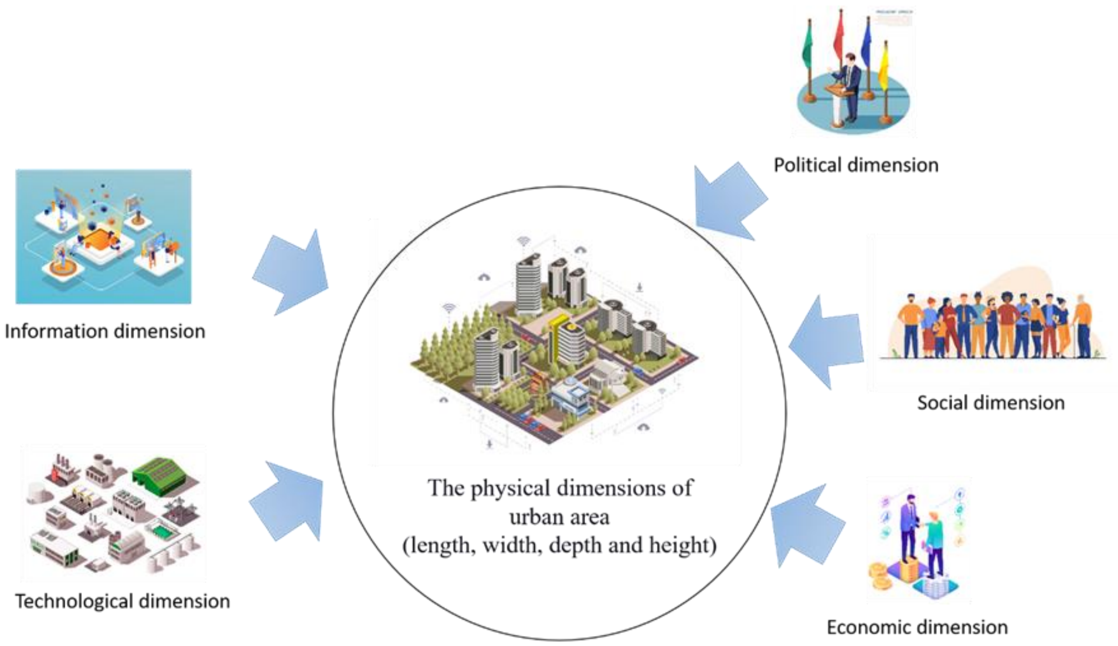

Figure 3. Multidimensionality of contemporary combat operations in urban areas

The communication means and digitalization push the boundaries of the area in which the forces are used. Because increasing the power of weapons in contemporary conditions, attacks are performed on a much wider scales, which includes the electromagnetic spectrum. By improving command and information systems in real-time, it is possible to increase the pace of execution of operations [11].

Precision

Three components allow precision in the execution of contemporary combat operations in urban areas: 1) timely and accurate information for making rational decisions, 2) consolidation of information into a single operational picture of the battlefield, and 3) simulation that allows elements of military forces to be formed on the basis of a developing crisis. These components give a new quality to the development and deployment of forces, the execution of various tasks, precise maneuverings and fire support, increased power protection, optimal logistics and optimal positioning of operational layout elements in time and space [11].

In preventive deployment operations, precision in deployment is as important as precision when hitting objects in attack and defensive operations. Counterterrorism and counterinsurgency operations accurately avoid civilian casualties and reduce collateral damage to facilities and infrastructure. Assistive operations populated by intelligence gathering in intelligence operations affect accuracy by gathering accurate and timely information about the enemy, space and time.

Nonlinearity

Nonlinearity is most obvious in connection with the physical space of urban areas. In contemporary conditions conducting combat operations in urban areas is characterized by the absence of precise organization of area to the front, depth and background. In urban areas, there is rarely a clear line of demarcation between the conflicting parties [11].

In offensive operations in urban areas, it is characteristic that combat activities are directed in several directions towards the centers of gravity of the defense's instead of the front along the entire line of contact with the enemy.

In defensive operations within urban areas, there are plenty of solid shelters inbuilt objects, but when the forces of the enemy enter a populated place, defenses are most often organized at resistance points with constant activity. The dispersion of forces within built structures, underground passages, streets and parks decentralizes the command of units on the ground. This decentralization combined with various tasks that can be obtained is usually achieved through the use of small units, complex command, combat identification, data exchange and target recognition [2].

Combat operations were moved to urban areas with acceptance of the risk of the independent action of units in the assigned zones of operation. The time dimension of nonlinearity is reflected in the simultaneous execution of various tasks and requirements for information networking of forces [11].

Distribution of the content of the actions

The distribution of the content of combat and non-combat actions in combat operations in urban areas is determined by the specifics of the urban areas where military operations are prepared and carried out. The dispersion of forces over a wide combat area requires the engagement of forces whe–rever and when it is necessary to achieve decisive effects, as opposed to concentrating on one the deciding point. The basis for the distribution of command and management, action and against actions, security, intelligence activities, maneuvers, fire support, protection of forces, and civil-military cooperation, is a unique development of the idea, parallel planning and coordination of all participants in the operation and directly depends on the use of command and information systems [11].

Simultaneity

Simultaneity in the actions of engaged forces in military operations in urban areas is enabled by the distribution of content. Military forces are used in a series of high-tempo actions in the zone of conducting military operations in an urban area to confront the enemy in a large number of completely different situations [11].

Almost all combat operations in urban areas were carried out much longer than expected at the beginning. The protracted battles of Khorramshahr during the Iran-Iraq War (1980-1988) and Kyiv, Ukraine (February-April 2022), halted the attackers from advancing longer than expected, leading to changes in operational and strategic plans (Figure 4) [2].

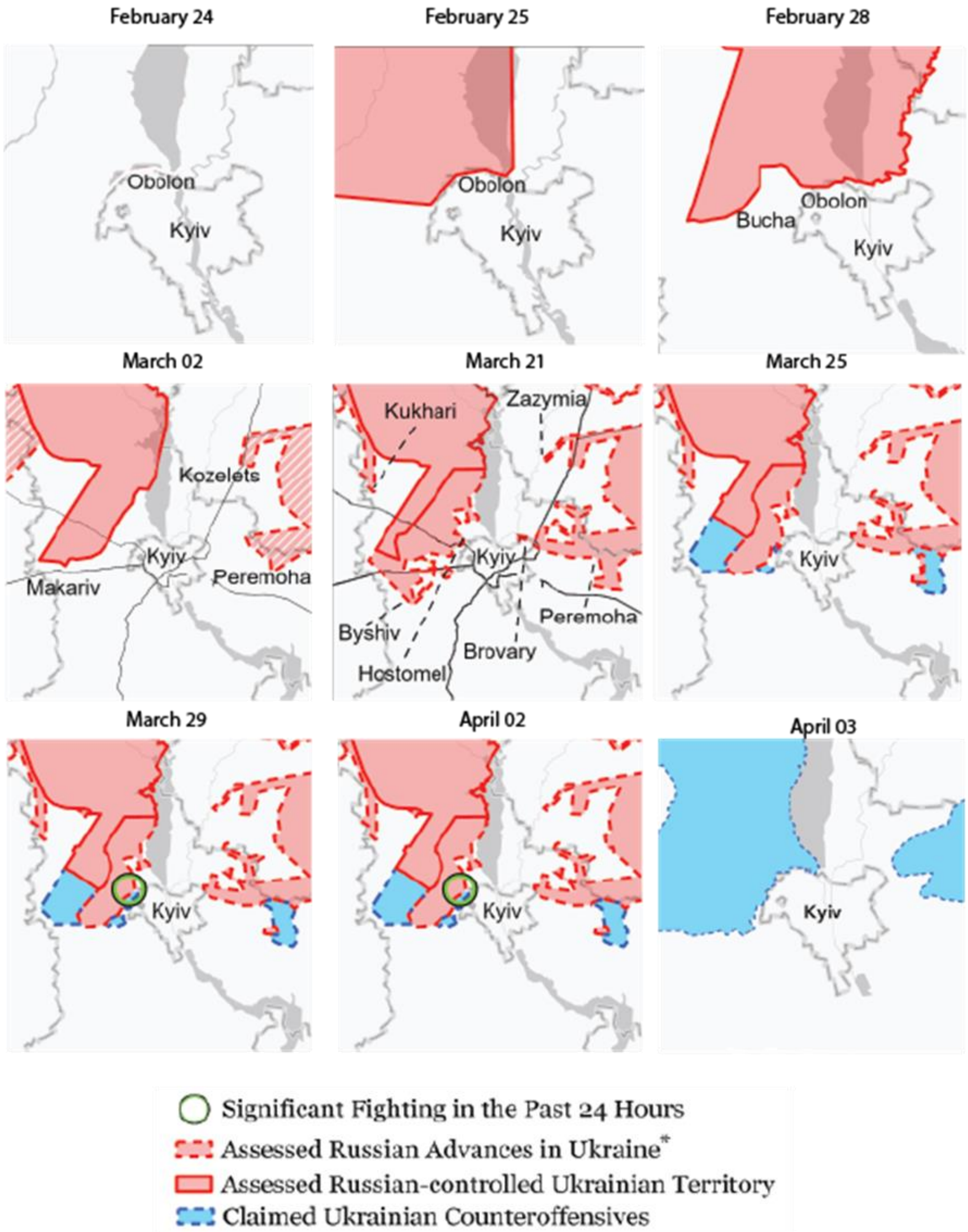

Figure 4: Battle of Kiev, Ukraine [12].

Integration military forces with civil society organizations

The result of carrying out combat operations in urban areas is many civilians, not military casualties [2]. Integration of military forces with civilian organizations in contemporary combat operations in urban areas requires the achievement of unity, despite the different priorities of participating organizations, many of which preserve their independence, freedom of action, and impartiality. In such conditions, the need for improving communications, planning, and interoperability with potential participants in contemporary operations is expressed [11].

Particular attention should be paid to the manner of marking targets within the limited space of the populated place. Dealing with the preparation of battlefields and data collection in the field is much more demandingly involved in operational planning. The results of dealing with the preparation of battlefields and data collection in the field can reduce the use of inadequate weapon systems and lead to the decision to strike targets with precision ammunition, thereby reducing collateral damage [2].

Interoperability

Interoperability is the ability of the joint and simultaneous operation of the military forces of different nations [11].

Combat operations carried out in urban areas have greater restrictions than operations in other areas. The presence of civilians and the need for the preservation of infrastructures greatly influence operations and help shape rules of engagement and rules for the use of force. The rules of engagement and the rules for the use of force determined for operations are often harmonized and refined according to the situation in order to limit collateral damage to civilians and their own forces while allowing flexibility in the execution of the mission. Most combat operations in urban areas since 1967, it has had one or more of the following limitations determined by the forces engaged: the fewer losses in their own forces; reduction to minimize civilian losses and/or collateral damage; or restrictions on the use of land-based weapons not of the army or air force and air defense [2].

Respect for international humanitarian law

Respect for international humanitarian law in military operations in the urban area requires knowledge and implementation of its provisions. International humanitarian law is a set of rules that, for humanitarian reasons, seek to limit the consequences of armed conflict. International humanitarian law protects persons who do not participate (or no longer participate) in hostilities and limits the means and methods of warfare [11].

The use of military force in contemporary operations in urban areas is based on the most important principles of international humanitarian law:

1. Proportionality, indicates the limited right to choose the means of carrying out actions. Life expectancy, injury to civilians, and damage caused by actions in a populated place must be proportionate to the military benefit derived from the actions (Article 22, Convention on the Laws and Customs of War on Land – IV Hague Convention);
2. Caution implies that the infliction of losses on civilians and the destruction of their property in a populated place are minimized.
3. Differentiation implies observing and respecting the differences between civilians and combatants and civilian and military objects in a populated place implies that only those actions which have a military justification can be taken and do not justify the excessive use of force, which is prohibited for the purpose of achieving goals in armed conflicts.

4. Humanity implies a focus on people, whereby it is considered that the treatment of both sick and injured obligations of all military forces in a populated place is considered to be lessened [11].

CONCLUSION

Armed conflicts have historically taken place around and in urban areas. In the 21st century, they are increasingly taking place within urban areas. The observed phenomenon in the place of armed conflicts coincides with the trend of expansion of urban areas.
Weaker armed forces tend to draw stronger armed forces into enclosed spaces in urban areas in order to minimize the effects of their weaknesses in human and material resources.
The stronger armed forces show an aspiration to bypass and avoid the development of armed conflicts in urban areas during their performances. On the other hand, when an operational situation forces that an armed conflict develops within urban areas, stronger armed forces tend to use all their material and human superiority, disproportionately using force, thereby causing damage or destruction of facilities and infrastructure systems of urban areas, and this leads to suffering and suffering of the civilian population.
The characteristics of modern armed conflicts, due to the characteristics of urban areas, manifest themselves quite differently compared to other areas. The main characteristics of urban areas are built buildings for housing and economy, basic communal infrastructure, and the presence of permanent residents. The main characteristics of modern armed conflicts in urban areas are multidimensionality, precision, nonlinearity in time and space of execution, distribution of content, simultaneity in action, integration of forces, interoperability, and the need to respect international humanitarian law in the use of military force.

Acknowledgements
This paper was written by compiling results from two scientific research projects funded by the Ministry of Defence, Republic of Serbia, number: VA-DH/1/22-24 "Defence system capability development management model" and VA-DH/1/21-23 "Influence of contemporary environment on the conduct of combat activities in urban spaces".

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SECTION

CARTOGRAPHY, GIS

& SPATIAL PLANNING

AN APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM TO EVALUATE THE WATER QUALITY OF ERGENE RIVER (TÜRKIYE)

DOI: https://doi.org/10.18509/GBP23161t
UDC: 528.8:004.6/.7]:556.11(282.247.1:560)

Cem Tokatli
Trakya University, Evrenos Gazi Campus, Edirne, **Türkiye**

ABSTRACT

Ergene River is the most significant watershed for the Thrace Region. However, it is one of the most polluted lotic ecosystems of Türkiye and known that exposed to an intensive domestic, agricultural and industrial pollution almost from its source region. The aim of this research was to determine the water quality of Ergene River by measuring a total of 15 significant water quality assessment parameters including dissolved oxygen (DO), oxygen saturation (%O2), pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, suspended solids (SS), nitrate (NO3), nitrite (NO2), ammonium (NH4), phosphate (PO4), sulphate (SO4), biological oxygen demand (BOD) and chemical oxygen demand (COD) and (2) to assess the water quality by using Geographic Information System (GIS). For this purpose, surface water samples were collected from 5 stations (from upstream to downstream; E1 – E5) located on the Ergene River in winter season (December) of 2020. As a result of this study, the mean recorded values of investigated water quality parameters in Ergene River were found as: 5.30 mg/L for DO, 46.50 % for %O2, 9.16 for pH, 743 μS/cm for EC, 502 mg/L for TDS, 0.50 ‰ for salinity, 186 NTU for turbidity, 136 mg/L for SS; 11.79 mg/L for NO3, 1.08 mg/L for NO2, 2.34 mg/L for NH4, 1.69 for PO4, 93.66 mg/L for SO4, 10.80 mg/L for BOD and 41. 16 mg/L for COD.

Keywords: Ergene River, Water quality, Geographic Information System

INTRODUCTION

In especially recent years, environmental pollution has become a global concern and contamination of freshwater ecosystems is top of attention for all over the world. Anthropogenic pressure on the freshwater resources is increasing day by day and accessing the clean water for many people in the world is also getting harder day by day [1 – 4]. Contamination by nutrients because of agrogenic and domestic discharges and also salinization of freshwater ecosystems because of industrial discharges are among the most significant problems for the freshwater ecosystems for all over the globe [5 – 7].
Ergene River Basin is knowns as the lifeblood of Thrace Region and known as one of the most contaminated freshwater habitats of Türkiye. It is adversely affected by the agricultural, industrial and domestic runoff caused from especially intensive paddy and sunflower cultivation and lots of settlements and dense industrial facilities located around the watershed [8 – 10]. The Ergene River is one of the main fluvial ecosystems located in the Thrace Region of Türkiye and it is the main sub - basin of Meriç River a significant cross boundary riverine ecosystem for the Europe. The length of the Ergene River is approximately 285 km from the source in the Yıldız Mountains to the point where it joins the Meriç River [11 – 13].

The main objectives of this investigation were (1) to assess the water quality of Ergene River by determining a total of 15 significant limnological parameters (dissolved oxygen, oxygen saturation, pH, electrical conductivity, total dissolved solids, salinity, turbidity, suspended solids, nitrate, nitrite, ammonium, phosphate, sulphate, biological oxygen demand and chemical oxygen demand) and (2) to evaluate the water quality by using Geographic Information System (GIS)

MATERIAL AND METHODS

Sample collection

In the present research, freshwater samples were collected from 5 locations selected on the Ergene River in rainy (winter) season of 2020. The topographic map of study area with the selected sampling points are given in Figure 1.

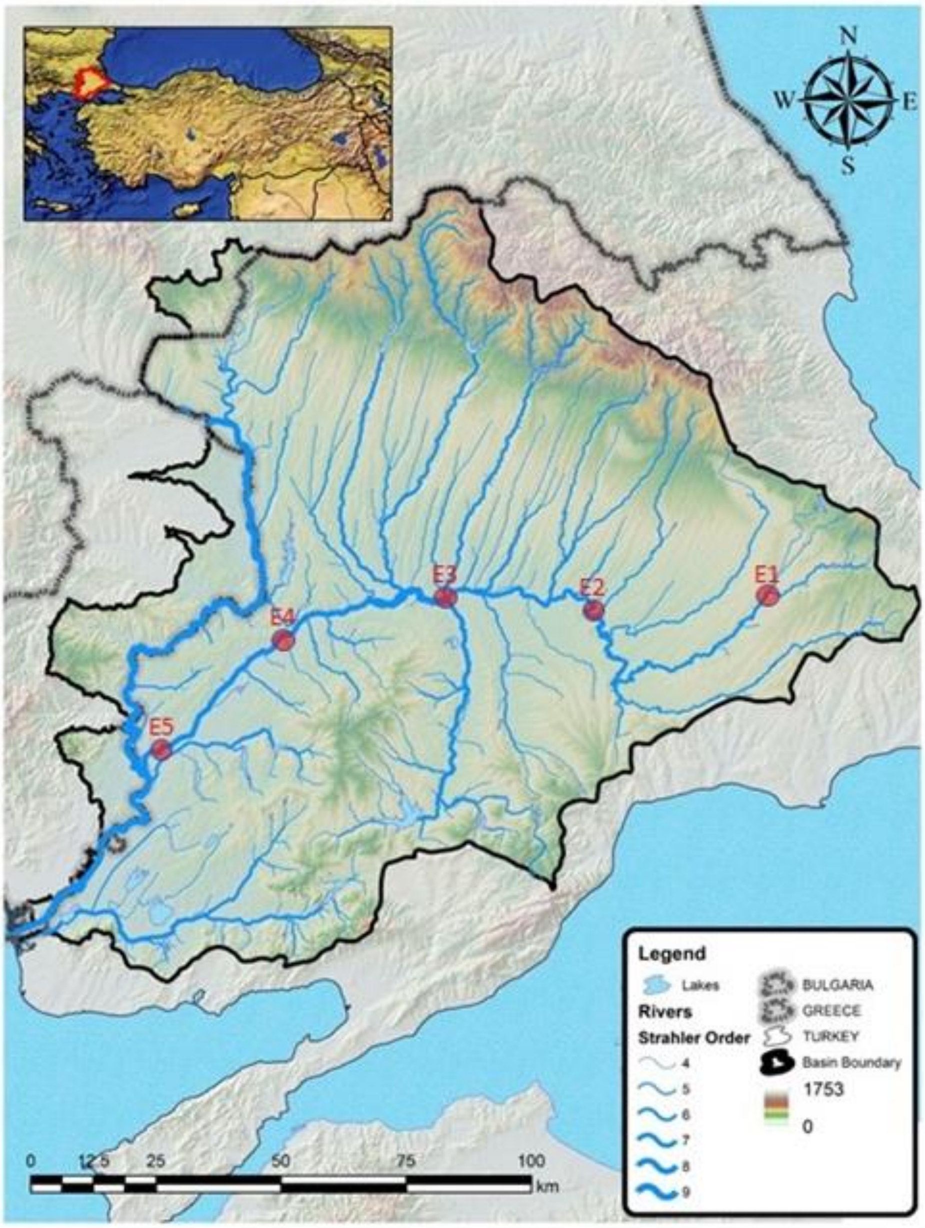

Figure 1. Ergene River Basin and selected stations

Psychochemical Analysis

Dissolved oxygen (DO), oxygen saturation (%O2), pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity variables were determined by using a multi – parameter device (Hach Lange – HQ40D) in the field studies; turbidity variable was determined by using a portable turbidimeter device (Hach Lange – 2100Q) in the field studies; suspended solids (SS) variable was determined by using gravimetric method in the laboratory studies; biological oxygen demand (BOD) variable was using a BOD device (Hach Lange – BOD Trak II) in the laboratory studies; nitrate (NO3), nitrite (NO2), ammonium (NH4), phosphate (PO4), sulphate (SO4) and chemical oxygen demand (COD) variables were determined by using a spectrophotometer device (Hach Lange – DR3900) in the laboratory studies.

RESULTS AND DISCUSSION

Significant spatial differences were detected for all of the investigated water quality parameters in the water of Ergene River. The results of measuring 15 limnological parameters in water of Ergene River are given in Table 1 and the GIS based distribution maps of investigated all of the parameters are given in Figure 2 – 5.

Table 1. Results of investigated variables

	E1	E2	E3	E4	E5
DO (mg/L)	7.96	1.90	2.27	6.71	7.67
%O_2	70.8	16.7	20.0	58.2	66.8
pH	9.75	8.83	8.96	9.20	9.07
EC (µS/cm)	287	1503	910	514	505
TDS (mg/L)	189	1038	596	345	344
Salinity (‰)	0.19	1.05	0.60	0.35	0.34
Turbidity (NTU)	32	54	187	333	327
SS (mg/L)	46	57	84	238	257
NO_3 (mg/L)	4.50	9.16	15.50	18.60	11.20
NO_2 (mg/L)	0.318	1.010	2.060	1.200	0.812
NH_4 (mg/L)	0.436	3.500	2.750	2.680	2.360
PO_4 (mg/L)	0.746	1.650	2.760	1.590	1.730
SO_4 (mg/L)	38	114	113	98	105
BOD (mg/L)	3.9	23.0	18.7	4.3	4.1
COD (mg/L)	25.1	69.1	52.8	30.9	27.9

The lowest dissolved oxygen and oxygen saturation values were measured at the E2 and E3 stations (1.90 – 2.27 mg/L for DO; 16.7 – 20.0 for %O2 respectively), while the highest dissolved oxygen and oxygen saturation values were measured at the E1 station (7.96 mg/L for DO; 70.8 for %O2). Similarly, the highest electrical conductivity, total dissolved solids, salinity, biological oxygen demand and chemical oxygen demand data were recorded at the E2 and E3 stations (1503 – 910 µS/cm for EC; 1038 – 596 mg/L for TDS; 1.05 – 0.60 ‰ for salinity; 23.0 – 18.7 mg/L for BOD; 69.1 – 52.8 mg/L for COD respectively), while the lowest data of these parameters were recorded at the E1 station (287 µS/cm for EC; 189 mg/L for TDS; 0.19 ‰ for salinity; 3.9 mg/L for BOD; 25.1 mg/L for COD) (Table 1).
A gradual increase in turbidity and suspended solids parameters from the upstream to the downstream of the Ergene River was detected. It was also noted that the values of nitrogen and phosphorus compound recorded in the middle and lower basin (excluding only the source region – E1) were at very high levels (Table 1).

In general, it has been determined that the upper basin of Ergene River has 1st class water quality, the middle basin of Ergene River has 3rd class water quality, and the lower basin of Ergene River has 2nd class water quality in terms of investigated water quality parameters [14].

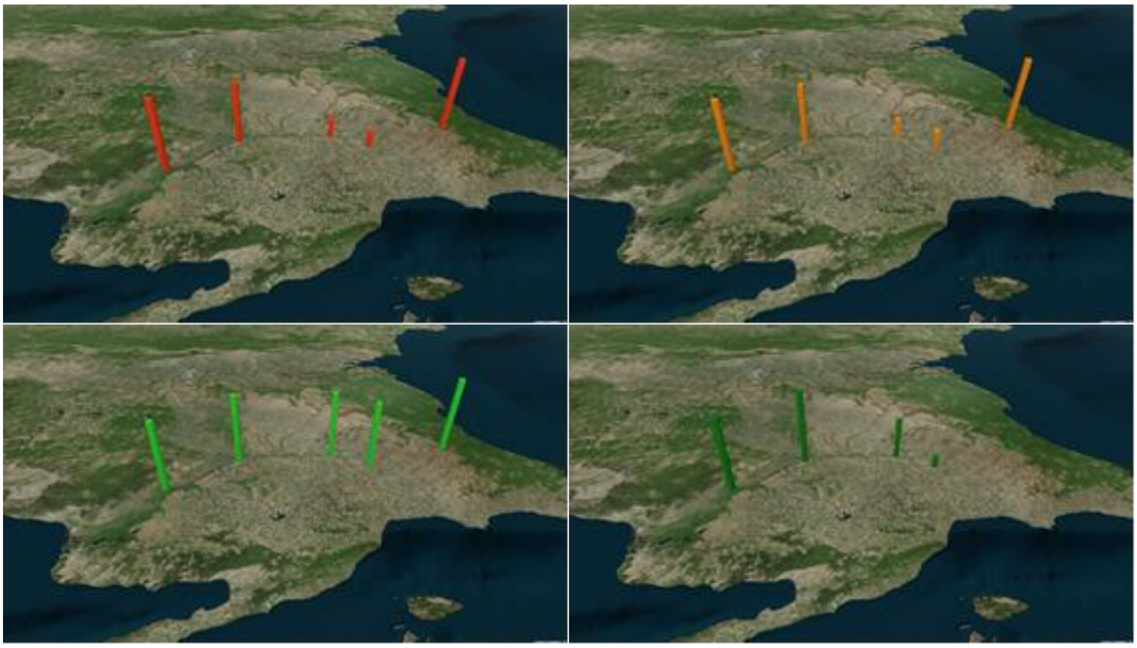

Figure 2. DO (up-left – mg/L), %O2 (up-right – %),
pH (down-left – pH), turbidity (down-right – NTU) levels

Figure 3. EC (up-left – μS/cm), TDS (up-right – mg/L),
Salinity (down-left – ‰), SS (down-right – mg/L) levels

The organic pollutant contents of the Ergene River, especially the phosphate and ammonium contents, were recorded as at very high levels in the whole basin waters. It has been noted that all the investigated stations from upstream to downstream have 3rd class water quality in terms of phosphate and ammonium values [14]. It is clearly documented that agricultural applications may significantly raise the concentrations of nitrogen and phosphorus compounds in soil and water [15 – 18]. There are many agricultural lands and industrial establishments in the Ergene River Basin. It is thought that the very high levels of organic pollutants and high salinization rates detected in the waters are caused by the agricultural and industrial activities carried out in the watershed.

Figure 4. NO3 (up-left – mg/L), NO2 (up-right – mg/L), NH4 (down-left – mg/L), PO4 (down-right – mg/L) levels

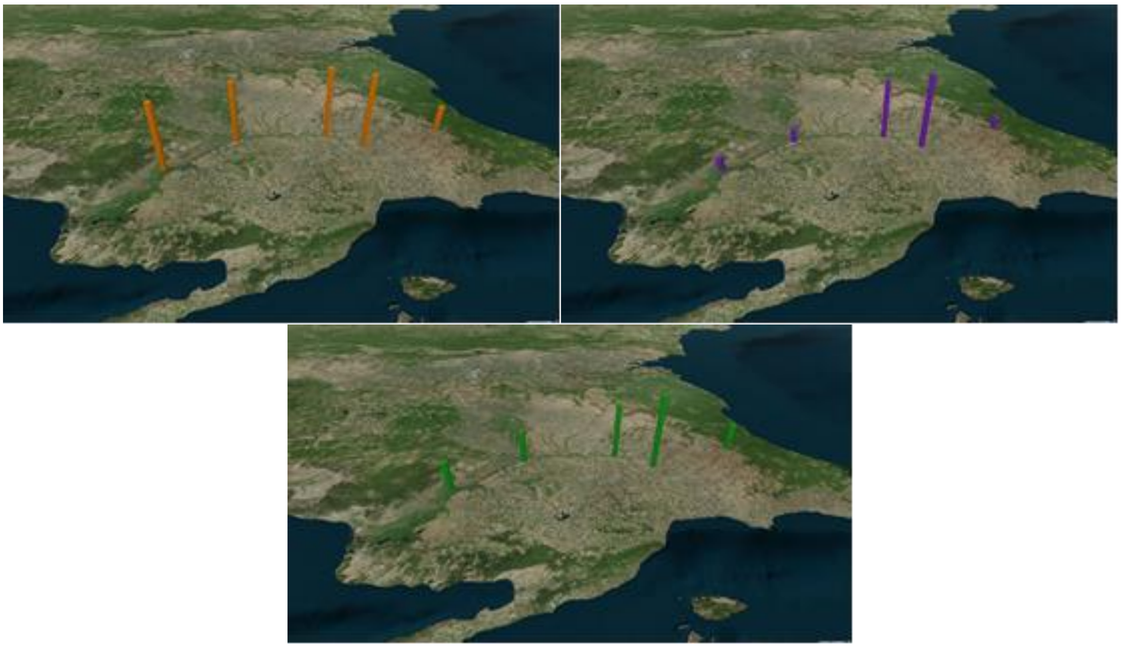

Figure 5. SO4 (up-left – mg/L), BOD (up-right– mg/L), COD (down-middle – mg/L) levels

In order to assess the pollution status of the investigated parameters in waters of the Ergene River, the levels of water quality parameters obtained from the current research were compared with those reported by previous investigations in Türkiye (Table 2).

The average levels of measured dissolved oxygen values in the water of Ergene River in the current research were lower than those in water of Tunca and Meriç Rivers and Emet, Seydisuyu and Havsa Streams. It was also determined that the average levels of measured EC, salinity, turbidity, nitrate, nitrite and phosphate values in the water of Ergene River in the current research were significantly higher than those in water of Tunca and Meriç Rivers and Emet, Seydisuyu and Havsa Streams [19 – 22].
These findings revealed that the concentrations of organic pollution parameters like nitrate, nitrite and phosphate and salinity parameters like EC and salinity of different lotic habitats varied significantly as a result of anthropogenic activities and natural sources. The current research was also clearly revealed that Ergene River is adversely affected by human-induced activities.

Table 2. Comparison of parameters in current study with other fluvial habitats

	DO mg/L	**pH**	**EC** µS/cm	**Sal** ‰	**Tur** NTU	**NO_3** mg/L	**NO_2** mg/L	**PO_4** mg/L	**Reference**
Ergene River	5.30	9.16	744	0.50	186	11.79	1.08	1.69	Current Research
Tunca River	8.44	8.25	679	0.37	7.99	1.47	0.04	0.27	[19]
Meriç River	8.67	8.22	327	0.18	6.17	1.90	0.02	0.16	[19]
Emet Stream	9.32	7.92	652	0.39	-	1.23	0.03	0.68	[20]
Seydisuyu Stream	8.13	7.92	543	0.29	-	11.31	0.02	0.57	[21]
Havsa Stream	-	8.19	402	0.19	35.30	0.93	0.02	0.62	[22]

DO: Dissolved oxygen; Sal: Salinity; Tur: Turbidity

CONCLUSION

In the present research, the water quality of Ergene River was investigated by measuring some significant limnological parameters. According to the result of this study, water of Ergene River was found as significantly contaminated by the organic pollutants mainly phosphate and ammonium.
In conclusion, it can be recommended that consequently, special measures should be taken to control the input of organic pollutants into the Ergene River and polyculture agricultural applications have to be supported to avoid using overly chemical fertilizers and pesticides around the region. Also discharges of industrial wastewaters without any treatment must be prevented in order to improve the quality and provide the sustainability of aquatic life in the Ergene River.
The data of the present research also reflects the applicability and necessity of GIS technology on evaluation the qualities of surface water ecosystems.

Acknowledgements
The present study was funded by the Trakya University, Commission of Scientific Research Projects (Project No. 2019/279).

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APPLICATION OF FUZZY LOGIC AND GIS IN THE RANKING OF LOCAL SELF-GOVERNMENT UNITS FROM THE ASPECT OF RELIEF SUITABILITY ON THE EXAMPLE OF JABLANICA AND PČINJA DISTRICTS, SERBIA

DOI: https://doi.org/10.18509/GBP23169n
UDC: 528.8:004.6/.7.021]:[551.4.037:352(497.11)

Ivan Novković[1]
Ana M. Petrović[2]
[1]University of Belgrade – Faculty of Geography, Belgrade, **Serbia**
[2]Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Belgrade, **Serbia**

ABSTRACT

The characteristics of relief are among the most important natural conditions, and the possibility of spatial utilization depends largely on them. The technique and density of construction, the development of infrastructure in a certain area, the possibility of carrying out certain activities, the dominance of one economic sector over another, depend on hypsometry, slope, aspect, vertical dissection and curvature of terrain. Therefore, it is important to thoroughly analyze these characteristics when planning spatial development, both at the state level and at the local community level. This paper analyzes the characteristics of the relief and then ranks the 13 local self-government units in the Jablanica and Pčinja districts in the Southern Serbia, according to those characteristics. The ranking took into account both quantitative criteria, such as the average height of the terrain, the average slope of the terrain, the percentage of the terrain surface with a slope of less than 5°, as well as more than 25°, the percentage of the terrain without curvature, etc., and qualitative criteria, such as the suitability of the relief forms, the relationship between relief and transport infrastructure, etc. Using GIS, the values of quantitative criteria were obtained for each unit of local self-government, and the qualitative criteria were evaluated by triangular fuzzy number. Then, using the Fuzzy Analytical Hierarchical Process (AHP), the weighting coefficients of each criterion were determined, and finally, using the Fuzzy MULTIMOORA method, the ranking of local self-government units was performed based on established criteria. The results obtained show the possibilities of local economic development in accordance with the characteristics of the relief with the possibility of efficient investments in certain units of local self-government, while, on the other hand, they show which units should be given more attention so that they do not lag behind in development..

Keywords: Hypsometry, Slope, Geographic Information System, Fuzzy AHP, Fuzzy MULTIMOORA

INTRODUCTION

Knowledge of natural conditions aims at a proper and rational approach in utilization of the natural potential of a certain territory, without significant disruptions to its natural balance. A complex analysis of the natural conditions of a certain area can determine its optimal usage [1]. One of the most important natural condition is the relief, and its characteristics, such as hypsometry, slope, aspect, vertical dissection and curvature of terrain, largely condition the possibility of using the space, conducting certain activities, and even determining which economic branch will be dominant. If the relief conditions are favourable, then they will provide great opportunities for engaging in certain activities and for the economic prosperity, while in the opposite case, they represent a limiting factor for the development of a certain territory. Therefore, it is important to thoroughly analyze the characteristics of relief when planning spatial development, both at the state level and at the local community level.

This research aims to rank the local self-government units, which belong to the Jablanica and Pčinja districts, Southern Serbia, from the aspect of relief suitability. Most of these units cannot boast of a level of economic development, which should be given much more attention in the future. In order for the ranking to be possible, a detailed analysis of the existing characteristics of the relief is required. Using Geographic Information Systems, the necessary data on relief characteristics was obtained, and by applying fuzzy logic the ranking of local self-government units was performed based on established criteria.

STUDY AREA

Study area consists of 13 local self-government units in the Jablanica and Pčinja districts, located in the Southern Serbia, bordering the Republic of North Macedonia and the Republic of Bulgaria. Out of 13 local self-government units, 2 have the status of cities, the city of Leskovac in Jablanica district and the city of Vranje in Pčinja district, while other 11 units are municipalities. Total research area is 6290 km^2, of which 2770 km^2 belongs to the Jablanica district, and 3520 km^2 to the Pčinja district. According 2011 and 2002 census data, research area had a population of about 432 thousand, each district about 216 thousand people. Average population density for research area is 69 inhabitants per square kilometre (Jablanica district 78, Pčinja district 61). This is one of the least developed parts of Serbia, with very unfavourable demographic situation. The municipality of Crna Trava is least populated local self-government unit in Serbia, also with the lowest population density.

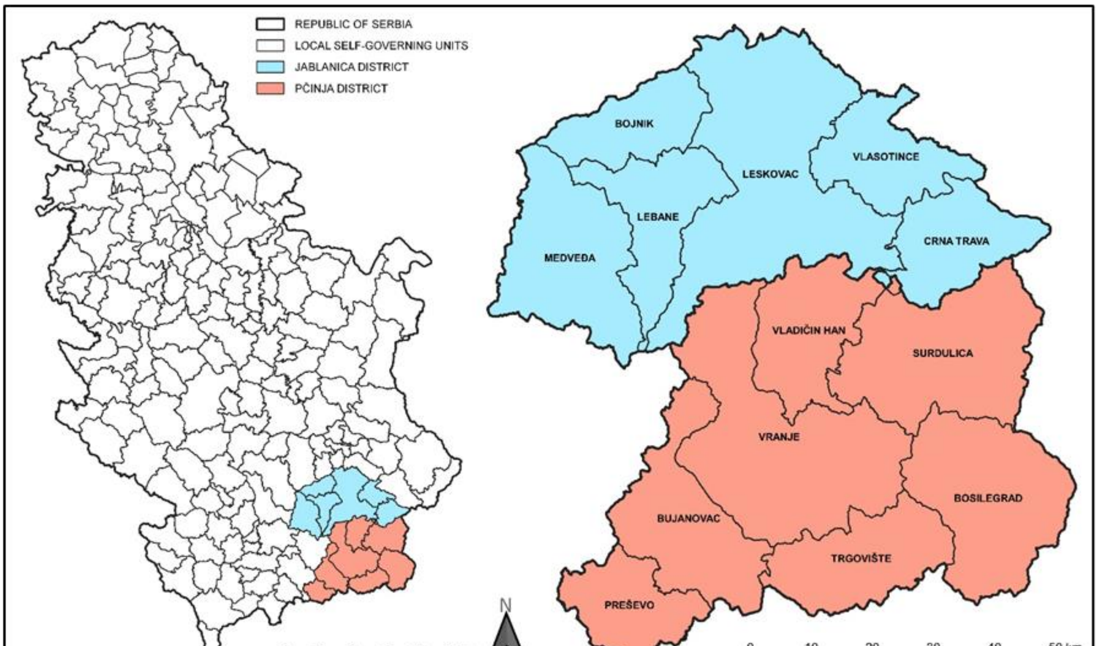

Figure 1. Local self-government units of the research area and their position in the Republic of Serbia

Table 1. Basic data of studied local self-government units

Local self-government units	Area [km^2]	Population	Population density [inh./ km^2]
Bojnik	263.9	11104	42.1
Crna Trava	312.0	1663	5.3
Lebane	336.8	22000	65.3
Leskovac	1025.0	144206	140.7
Medveđa	524.3	7438	14.2
Vlasotince	307.9	29893	97.1
Bosilegrad	571.2	8129	14.2
Bujanovac	460.9	43302	94.0
Preševo	264.7	34904	131.9
Surdulica	628.4	20319	32.3
Trgovište	370.6	5091	13.7
Vladičin Han	365.8	20871	57.0
Vranje	858.4	83524	97.3

Largest part of the research area belongs to the Black Sea drainage basin, with Južna Morava River as the main watercourse, while south-eastern part of research area belongs to the Aegean Sea basin, with Pčinja River and Dragovištica River as main watercourses. Južna Morava River valley has great agricultural and tourist potential, but also a very important traffic function. It is a natural route for the railway and highway Belgrade-Skopje-Thessalonica [2].

Average altitude of research area is 711 m (Jablanica district 588 m, Pčinja district 915 m). Lowest point of research area is exit of Južna Morava River riverbed out of the research area with an altitude of 191 m a.s.l., and the highest point is on Mt Besna Kobila with an altitude of 1923 m a.s.l. Average terrain slope of the research area is 12.5° (Jablanica district 10.8°, Pčinja district 13.8°).

RESEARCH METHODOLOGY

The ranking of the researched local self-government units from the aspect of relief suitability was performed using fuzzy logic with the help of Geographic Information Systems. The first step in the analysis is the selection of criteria on the basis of which the ranking is made. Criteria can be positive, where the priority will be higher as their value is higher, and negative, where the situation is opposite. The criteria that were taken into account for the purposes of this paper are: average altitude, average slope, transport accessibility, share of areas with slopes under 5°, share of areas with slopes over 25°, share of areas with altitude over 1000 m, suitability of the relief forms and processes, share of suitable areas around watershed, as well as share of areas with flat slopes between 5° and 25° (Table 2).

The criteria can be quantitative, whose values were obtained by analyzing geospatial data through GIS and expressed with appropriate units of measure, as well as quantitative, whose value are expressed by a triangular fuzzy number. In this case, a triangular fuzzy number was used, which represents the basic component of the fuzzy system [3]. Data on the average terrain height, average slope, share of areas with slopes under 5°, share of areas with slopes over 25°, share of areas with altitude over 1000 m, share of suitable areas around watershed, as well as share of areas with flat slopes between 5° and 25° were derived from 25x25 m cell size EU-DEM terrain model [4] using QGIS software. Values for the transport accessibility were assigned by reviewing the relationship between road infrastructure, especially state roads of first and second order, and relief forms, especially river valleys. Values for the suitability of the relief forms and processes were assigned by analyzing qualitative and quantitative characteristic of relief forms from various topographical and geomorphological maps.

Table 2. Ranking criteria and their weighting coefficients

Number	Criterion	Unit	Positive/ negative	Weighting coefficient (W)
1	Average altitude	m	negative	0.1435
2	Average slope	deg	negative	0.1358
3	Transport accessibility	fuzzy number	positive	0.1283
4	Areas with slopes under 5°	%	positive	0.1243
5	Areas with slopes over 25°	%	negative	0.1167
6	Areas with altitude over 1000 m	%	negative	0.1076
7	Suitability of the relief forms and processes	fuzzy number	positive	0.0982
8	Suitable areas around watershed	%	positive	0.0853
9	Areas with flat slopes between 5° and 25°	%	positive	0.0603

Given that not all criteria are of equal importance, assigning of the weight coefficients to the criteria is necessary. It was performed through the fuzzy Analytical Hierarchy Process (AHP). Fuzzy AHP is a technique of incorporating the fuzziness of human thoughts into decision making [5]. In the fuzzy AHP model, a combination of AHP and fuzzy sets is used to assign weights to the corresponding factors [6]. The first stage of the fuzzy AHP method involves creating a fuzzy criteria comparison matrix. After that, it is necessary to calculate the value of the synthetic fuzzy extension for each element [7]. Further, the degree of possibility that the convex fuzzy number of a given criterion is greater than the convex number of other criteria is analyzed [8]. The weight vector is derived from the previous step, and through normalization, the vector is reduced to the form of a weight coefficient [9].

Table 3. Fuzzy criteria comparison matrix

Criterion	1	2	3	4	5	6	7	8	9
1	1; 1; 1	0.5; 1.5; 2.5	0.6; 1.6; 2.6	0.7; 1.7; 2.7	0.8; 1.8; 2.8	1; 2; 3	1.2; 2.2; 3.2	1.5; 2.5; 3.5	1.75; 2.75; 3.75
2	0.4; 0.67; 2	1; 1; 1	0.5; 1.5; 2.5	0.6; 1.6; 2.6	0.7; 1.7; 2.7	0.8; 1.8; 2.8	1; 2; 3	1.2; 2.2; 3.2	1.5; 2.5; 3.5
3	0.38; 0.63; 1.67	0.4; 0.67; 2	1; 1; 1	0.5; 1.5; 2.5	0.6; 1.6; 2.6	0.7; 1.7; 2.7	0.8; 1.8; 2.8	1; 2; 3	1.2; 2.2; 3.2
4	0.37; 0.59; 1.43	0.38; 0.63; 1.67	0.4; 0.67; 2	1; 1; 1	0.6; 1.6; 2.6	0.7; 1.7; 2.7	0.8; 1.8; 2.8	1; 2; 3	1.2; 2.2; 3.2
5	0.36; 0.56; 1.25	0.37; 0.59; 1.43	0.38; 0.63; 1.67	0.38; 0.63; 1.67	1; 1; 1	0.6; 1.6; 2.6	0.7; 1.7; 2.7	0.8; 1.8; 2.8	1.2; 2.2; 3.2
6	0.33; 0.5; 1	0.36; 0.56; 1.25	0.37; 0.59; 1.43	0.37; 0.59; 1.43	0.38; 0.63; 1.67	1; 1; 1	0.6; 1.6; 2.6	0.7; 1.7; 2.7	1; 2; 3
7	0.31; 0.45; 0.83	0.33; 0.5; 1	0.36; 0.56; 1.25	0.36; 0.56; 1.25	0.37; 0.59; 1.43	0.38; 0.63; 1.67	1; 1; 1	0.6; 1.6; 2.6	1; 2; 3
8	0.29; 0.4; 0.67	0.31; 0.45; 0.83	0.33; 0.5; 1	0.33; 0.5; 1	0.36; 0.56; 1.25	0.37; 0.59; 1.43	0.38; 0.63; 1.67	1; 1; 1	0.8; 1.8; 2.8
9	0.27; 0.36; 0.57	0.29; 0.4; 0.67	0.31; 0.45; 0.83	0.31; 0.45; 0.83	0.31; 0.45; 0.83	0.33; 0.5; 1	0.33; 0.5; 1	0.36; 0.56; 1.25	1; 1; 1

The final stage of the procedure is the calculation of the consistency of the comparison matrix. The comparison matrix, created using a triangular fuzzy number, requires a defuzzification process. Furthermore, it is necessary to calculate the degree of consistency (CR), which represents the ratio of the consistency index (CI) and the random index (RI), whose value depends on the number of compared criteria. The results of the comparison are considered consistent if the condition CR < 0.10 is met [3,9]. In this case, the consistency coefficient is 0.058, which means that the consistency of the fuzzy matrix is satisfactory.

After determining the weighting coefficients of the criteria, the ranking of local self-government units was performed using the fuzzy MULTIMOORA method. MULTIMOORA includes three or more methods that control each other and rank alternatives depending on their performance values [10]. Multi-objective optimization based on ratio analysis plus the full multiplicative form – MULTIMOORA, is a technique for making decisions using multi-criteria analysis, based on the results of three methods: The Ratio System, Reference Point Approach and Full Multiplicative Form [11]. In this case, it is about the application of the fuzzy MULTIMOORA method, given that the weighting coefficients were assigned using the fuzzy AHP method, and the qualitative criteria for each local self-government unit were evaluated with a triangular fuzzy number.

The three mentioned methods that rank the local self-government units according to the selected criteria are applied to for each local self-government unit, and the final rank of the local self-government units is obtained based on the mean value of the rank of all three applied methods. Before applying the methods, it is necessary to normalize the values assigned to the local self-government units for each criterion, in order to make it possible to compare the values expressed in different measurement units and the values expressed by the triangular fuzzy number. First, the coefficient for normalization is calculated, which is equal to the square root of the average sum of squares of all values for a given criterion, and then each value of a given criterion is divided by the coefficient for normalization of that criterion [10].

When applying the Fuzzy Reference Point Approach (FRPA) method, for each criterion, the minimum value of all local self-government units is subtracted from the values obtained by dividing by the coefficient for normalization, if it is negative criteria, while for positive criteria, it is subtracted from the maximum value of all local self-government units' value for a given local self-government unit. The values obtained in this way are multiplied with the weight criteria obtained by applying the fuzzy AHP method and then their comparison is made, so that only the highest value of all criteria for a given local self-government unit is taken into account for the ranking. The first in rank will be the local self-government unit with the smallest value, while the last one will be the one with the highest value [10].

When applying the Fuzzy Ratio System (FRS) method, for positive criterion, the quotients of the values assigned to a specific local self-government unit for that criterion and the normalization coefficient added, and then quotients of all negative criterions and their normalization coefficients are subtracted from them. The local self-government unit with the highest value of the results is the first in rank. When applying the Fuzzy Full Multiplicative Form (FFMF) method, the values of the positive criteria for each local self-government unit are multiplied, which are then divided by the values of the negative criteria. The first in rank is the local self-government unit with the highest value of the result, just as in case of the application of the Fuzzy Ratio System method [10].

RESULTS AND DISCUSSIONS

Terrain hypsometry is one of the most important natural conditions. Hypsometric characteristics of the relief represent the basis of all further research and give a more comprehensive idea of the analyzed terrain. On the basis of the hypsometry, we come to knowledge whether it is a plain, hilly-mountainous or mountainous terrain, and depending on the altitude of the terrain, the possibilities of its planning and proper use also arise [2,12]. With the increase in altitude, the change of other natural conditions such as air temperature, precipitation amount, snow cover, type of vegetation etc. occurs. Also, the possibility to engage in many activities decreases, the composition of the air changes, and the number of agricultural crops that can be grown is reduced.

The average altitude of the terrain represents an indispensable data in calculating the intensity of erosive processes, sediment retention etc. [2,12]. Therefore, the average altitude of the terrain is the criterion with the highest weighting coefficient, in relation to the other criteria, and its value is 0.14 (Table 2). The municipality of Bojnik, with average altitude of 412 m a.s.l., is the local self-government unit with lowest average altitude among others in research area, which gives it least disadvantages considering terrain utilization from this point of view. The municipality of Bojnik is followed by the city of Leskovac, with average altitude of 450 m a.s.l., and the municipality of Lebane, where average terrain altitude is 475 m (Table 4). Local self-government unit with the highest average altitude is the municipality of Bosilegrad with average altitude of 1228 m a.s.l., followed by the municipality of Crna Trava (1162 m) and Surdulica (1141 m).

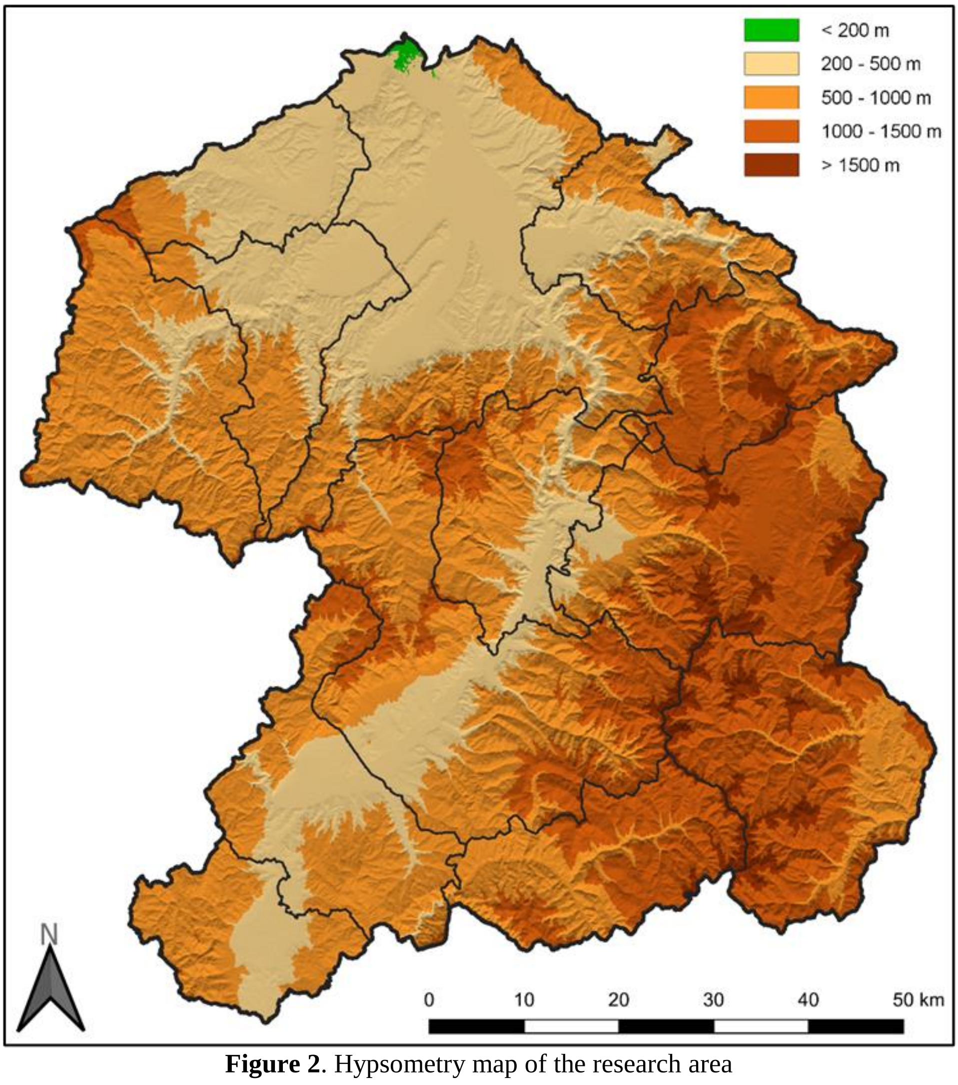

Figure 2. Hypsometry map of the research area

Table 4. Evaluated criteria for each local self-government unit

Local self-governing units	Average altitude (-)			Average slope (-)			Transport accessibility (+)		
Bojnik	412	412	412	5.3	5.3	5.3	4	5	6
Crna Trava	1162	1162	1162	16.8	16.8	16.8	1	2	3
Lebane	475	475	475	8.7	8.7	8.7	3	4	5
Leskovac	450	450	450	8.8	8.8	8.8	4	5	6
Medveđa	692	692	692	13.8	13.8	13.8	2	3	4
Vlasotince	569	569	569	13.0	13.0	13.0	2	3	4
Bosilegrad	1228	1228	1228	17.6	17.6	17.6	2	3	4
Bujanovac	628	628	628	9.1	9.1	9.1	3	4	5
Preševo	632	632	632	8.5	8.5	8.5	3	4	5
Surdulica	1141	1141	1141	14.1	14.1	14.1	2	3	4
Trgovište	1069	1069	1069	16.4	16.4	16.4	1	2	3
Vladičin Han	690	690	690	14.0	14.0	14.0	3	4	5
Vranje	812	812	812	13.9	13.9	13.9	3	4	5
Local self-governing units	Areas with slopes under 5° (+)			Areas with slopes over 25° (-)			Areas with altitude over 1000 m (-)		
Bojnik	55.9	55.9	55.9	0.3	0.3	0.3	4.3	4.3	4.3
Crna Trava	4.3	4.3	4.3	14.3	14.3	14.3	75.7	75.7	75.7
Lebane	33.6	33.6	33.6	1.5	1.5	1.5	0.5	0.5	0.5
Leskovac	40.2	40.2	40.2	4.1	4.1	4.1	3.0	3.0	3.0
Medveđa	7.2	7.2	7.2	5.3	5.3	5.3	4.2	4.2	4.2
Vlasotince	17.7	17.7	17.7	7.4	7.4	7.4	6.5	6.5	6.5
Bosilegrad	4.1	4.1	4.1	15.4	15.4	15.4	78.5	78.5	78.5
Bujanovac	27.1	27.1	27.1	1.7	1.7	1.7	7.8	7.8	7.8
Preševo	37.3	37.3	37.3	1.6	1.6	1.6	0.7	0.7	0.7
Surdulica	12.1	12.1	12.1	9.6	9.6	9.6	71.6	71.6	71.6
Trgovište	4.0	4.0	4.0	9.9	9.9	9.9	60.3	60.3	60.3
Vladičin Han	12.0	12.0	12.0	9.1	9.1	9.1	13.1	13.1	13.1
Vranje	16.4	16.4	16.4	9.6	9.6	9.6	27.5	27.5	27.5
Local self-governing units	Suitability of the relief forms and processes (+)			Suitable areas around watershed (+)			Areas with flat slopes between 5° and 25° (+)		
Bojnik	3	4	5	10.8	10.8	10.8	1.8	1.8	1.8
Crna Trava	2	3	4	11.6	11.6	11.6	0.9	0.9	0.9
Lebane	2	3	4	8.0	8.0	8.0	1.0	1.0	1.0
Leskovac	2	3	4	5.5	5.5	5.5	1.1	1.1	1.1
Medveđa	2	3	4	6.3	6.3	6.3	0.6	0.6	0.6
Vlasotince	2	3	4	5.8	5.8	5.8	0.9	0.9	0.9
Bosilegrad	2	3	4	7.9	7.9	7.9	0.8	0.8	0.8
Bujanovac	2	3	4	6.3	6.3	6.3	1.1	1.1	1.1
Preševo	2	3	4	7.6	7.6	7.6	0.9	0.9	0.9
Surdulica	3	4	5	7.8	7.8	7.8	1.1	1.1	1.1
Trgovište	1	2	3	5.6	5.6	5.6	0.7	0.7	0.7
Vladičin Han	1	2	3	7.1	7.1	7.1	0.7	0.7	0.7
Vranje	2	3	4	5.8	5.8	5.8	0.8	0.8	0.8

Since altitude of 1000 m represents conditional border for intensive agricultural activity in Serbia [12], and that there is a rapid decrease in suitability for conducting various activities, one of the criteria that was used for this research is share of areas with altitude over 1000 m a.s.l in total areas of each local self-government unit. This criterion is the sixth most important with a weight coefficient value of 0.11 (Table 2). Largest share of areas with altitude over 1000 m are found in the municipality of Bosilegrad, with 78.5% of total municipality area. Second largest share of such areas is found in the municipality of Crna Trava, with 75.7% of total area, and third is the municipality of Surdulica with 71.6% of total area (Table 4). Local self-government unit with the lowest share of areas with altitude over 1000 m is the municipality of Lebane, with only 0.5% of total area, followed by the municipality of Preševo (0.7%), and the city of Leskovac (3%).

The slope of the terrain, along with hypsometry, is one of its most important characteristics. The ability to engage in certain activities, as well as their efficiency, largely depends on the slope of the terrain. The slope affects temperature fluctuations and other climatic elements, due to the different incidence angle of the sun's rays in combination with the aspect. Steeper slopes reduce the possibility of applying agrotechnical measures in agriculture, an increased slope significantly increases the fuel consumption of agricultural vehicles and reduces work productivity, while reducing the yield of most agricultural crops. A higher slope angle of the terrain reduces the suitability for the construction of settlements and infrastructure and significantly increases construction costs. On the other hand, terrains with a greater slope are favourable for engaging in certain types of tourism and recreation [12]. The slope of the relief is one of the basic factors that defines the intensity of soil erosion process. This is conditioned by the fact that as the slope of the terrain increases, so does the kinetic energy of the water flowing down the slope. Therefore, the same amount of water on a horizontal and an inclined surface has different energy and can erode a much larger amount of material [2,12].

The average terrain slope gives a picture of what the overall utilization of the terrain is possible in relation to suitability of the terrain. Therefore, in this work, it is the second most important criterion with a weight coefficient value of almost 0.14 (Table 2). The municipality of Bojnik, with average slope 5.3° is the local self-government unit with lowest average slope, while second and third ranked are the municipality of Preševo, with average slope of 8.5° and the municipality of Lebane, with 8.7° (Table 4). Local self-government unit with steepest average slope is the municipality of Bosilegrad where average slope is 17.6°, followed by the municipality of Crna Trava (16.8°) and Trgovište (16.4°).

Beside average slope, it is important to determine what is the share of areas with the slope under 5°, as well as over 25°. Terrains with slopes under 5° are suitable for most of the activities, while their productivity is at maximum. Possibility for construction of the objects and infrastructure is highest and also highest productivity and yield in agriculture is present. It should not be forgotten that risk of the slope processes on such terrains is lowest. The limitations of such terrains arise from other characteristics, such as the relationship with underground water and flood zones, geological characteristics, etc. The weight coefficient value of this criterion is 0.12 (Table 2). In the research area, highest share of areas with the slopes under 5° are found in the municipality of Bojnik, with 55.9% of total municipality area. Second ranked is the city of Leskovac with 40.2% of total area, and third is the municipality of Preševo with 37.2% of total area (Table 4). Local self-government unit with the lowest share of areas with terrain slope under 5° is the municipality of Trgovište, with 4% of total area, followed by the municipality of Bosilegrad (4.1%), and the municipality of Crna Trava (4.3%).

Terrains with slopes over 25° have quite opposite characteristics comparing to above-mentioned. Number of activities that can be conducted on such terrains is much smaller and productivity of the most activities that are conducted on such terrain is very reduced. Risk of slope processes and natural disasters that arise from such processes (torrential floods, landslides, rockfalls, avalanches) is high, if other conditions are met. Such areas have a higher energy of mass movement and they affect the velocity of water flow and the development of erosion processes [13,14]. The weight coefficient value of this criterion is almost 0.12 (Table 2). Largest share of areas with terrain slope over 25° are found in the municipality of Bosilegrad, with 15.4% of total municipality area. Second largest share of such areas is found in the municipality of Crna Trava, with 14.3% of total area, and third is the municipality of Trgovište with 9.9% of total area (Table 4). Local self-government unit with the lowest share of areas with terrain slope over 25° is the municipality of Bojnik, with only 0.3% of total area, followed by the municipality of Lebane (1.5%), and the municipality of Preševo (1.6%).

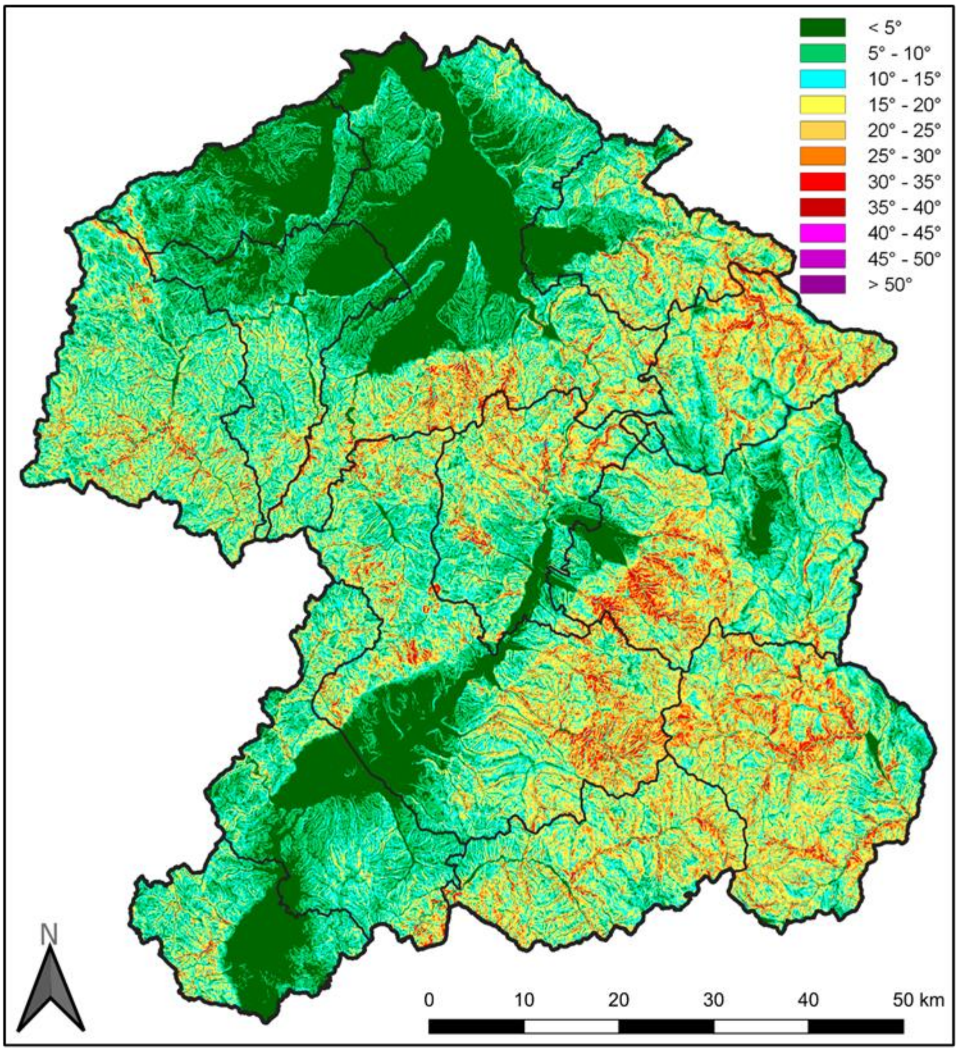

Figure 3. Terrain slope map of the research area

Besides surfaces in wider river valleys, which are considered as one of the most suitable, in determining the overall suitability of the relief, it is necessary to take into account suitable areas around the top of watershed of all river basins in research area. Such areas, if terrain slope is low, could be favorable for various activities, and limitation of their use, first of all comes from their accessibility. Such areas were determined first by calculating relative slope position in QGIS software, using EU-DEM as basic input data, and then taking into account only areas where value of relative slope position is higher than 0.975. The weight coefficient value of this criterion is lower than 0.09 (Table 2). Largest share of suitable areas around the top of watershed is present in the municipality of Crna Trava, with 11.6% of total municipality area. Second largest share of such areas is found in the municipality of Bojnik, with 10.8% of total area, and third is the municipality of Lebane with 8% of total area (Table 4). Local self-government unit with the lowest share of suitable areas around the top of watershed is the city of Leskovac, with 5.5% of total area, followed by the municipality of Trgovište (5.6%), while third place is shared by the municipality of Vlasotince and the city of Vranje (5.8%).

Terrain curvature is the amount of terrain deviation along a certain line from a straight line [15]. It is the second derivative of the topographic surface and represents the degree of change of the first derivative, such as slope and exposure, in a certain direction [16]. Most often, profile (vertical) curvature and planform (tangential, horizontal) curvature are calculated, which determine whether the terrain is flat, convex or concave, in the direction of greatest slope or isohypse. Combining profile and planform curvature cases gives 9 different classes of terrain curvature, where vertically flat and horizontally flat slopes are most suitable for conducting in various activities. For purposes of these research such slopes, with angle between 5° and 25° were taken into account. Terrains with slope angles below 5° and above 25° were already analyzed in this paper regardless their curvature, since on such terrains they do not modify suitability in larger amount. Taking into account that targeted areas cover very small share of total areas of slope angles between 5° and 25°, weight coefficient of this criterion is lowest, with the value of 0.06 (Table 2). Largest share of such areas in research area is in the municipality of Bojnik (1.8%), and lowest is in the municipality of Medveđa (0.6%).

Transport accessibility is important from the point of terrain utilization and future development. Wide river valleys give possibilities to develop traffic infrastructure and to easily connect parts inside one local self-government unit, areas in different units. On the other hand, narrow valleys and high dissection relief forms significantly lower connection possibilities. This is the third most important criteria, with a weight coefficient value of 0.13 (Table 2). The highest value for this criterion is assigned to the city of Leskovac and the municipality of Bojnik, where river valleys of Južna Morava River and its tributaries are widely open, allowing good connectivity in a large part of those units, while the lowest value is given to the municipalities of Crna Trava and Trgovište (Table 4), where narrow valleys and lack of flat terrain represent a problem for building new and improving existing traffic infrastructure.

The possibility of space utilization will depend on the relief forms, their dimensions and other characteristics, therefore relief forms were evaluated for the purpose of this paper. Also, geomorphological processes and their intensity were also taken into account, especially erosion intensity and landslide process, since they can directly and indirectly present a limitation to terrain utilization and development. The weight coefficient value for this criterion is 0.1 (Table 2). Highest values for the suitability of relief forms and processes was given to the municipalities of Bojnik and Surdulica, and the lowest to the municipalities of Trgovište and Vladičin Han (Table 4).

By evaluating all the criteria for the investigated local self-government units, as well as by applying the fuzzy MULTIMOORA method, their ranking was performed from the aspect of the relief suitability. According to the Fuzzy Reference Point Approach (FRPA) method, the municipality of Bojnik is most suitable from the aspect of relief, followed by the city of Leskovac and the municipality of Preševo, while the municipalities of Trgovište, Bosilegrad and Crna Trava, are marked as units with the lowest suitability (Table 5).

According to the Fuzzy Ratio System (FRS) method, the municipality of Bojnik also has the highest suitability. The city of Leskovac is again ranked as second, while the municipality of Lebane is at third place. The last in relief suitability according to this method is the municipality of Bosilegrad (Table 5).
According to the Fuzzy Full Multiplicative Form (FFMF) method, as in the previous two cases, ranked as first is also the municipality of Bojnik. The municipality of Lebane is ranked as second, and the municipality of Preševo is third. The last in relief suitability according to FFMF method is the municipality of Trgovište (Table 5).

Table 5. Ranked local self-government units from the aspect of relief suitability

Local self-governing units	FRPA	FRS	FFMF	FINAL RANK
Bojnik	1	1	1	1
Crna Trava	11	12	11	11
Lebane	4	3	2	3
Leskovac	2	2	4	2
Medveđa	10	7	7	7
Vlasotince	6	6	6	6
Bosilegrad	12	13	12	12
Bujanovac	5	5	5	5
Preševo	3	4	3	4
Surdulica	8	10	10	10
Trgovište	13	11	13	12
Vladičin Han	9	8	8	8
Vranje	7	9	9	8

According to the final ranking, which takes into account the results of all three applied techniques within the fuzzy MULTIMOORA method, the highest suitability of the relief has the municipality of Bojnik, which is the first ranked according to all three applied techniques (Table 5). This municipality is best in most of categories, it has lowest average altitude of the terrain, lowest average slope, highest transport accessibility and suitability of the relief forms and processes, highest share of areas with slope below 5°, lowest above 25°, and highest share of flat terrains with slopes between 5° and 25°. Sadly, the municipality of Bojnik is not as near developed as it should be, according to the relief suitability, even within the surveyed districts. Hopefully future development plans and investments could take into account this kind of research, which could significantly improve the situation.
The city of Leskovac is second by final ranking, and before 1990s it was using this potential notably, standing out as an economic leader in this part of Serbia. Unfortunately, the suitability of the relief could not affect the socioeconomic processes that negatively affected the state of this local community in past decades. Third in final ranking is the municipality of Lebane, which is also not as near developed as it could be, according to its relief suitability. Last in final rank are the municipalities of Trgovište and Bosilegrad (Table 5), where relief proved to be one of the limiting factors of development, and taking into account their demographic situation, there is a little chance that the situation will improve significantly in the near future. This also applies to the municipality of Crna Trava, which is ranked just before last two municipalities.
When viewed from the district's point of view, Jablanica district has better situation than Pčinja district. First three ranked local self-government units are all from the Jablanica district, and only the municipality of Crna Trava has very low rank. When looking Pčinja district, first in rank is the municipality of Preševo, second is the municipality of

Bujanovac, and third place is divided by the city of Vranje and the municipality of Vladičin Han. All of those local self-government units should find a way to use relief suitability much better in the future.

CONCLUSIONS

Although socioeconomic factors are the main factors when it comes to development, but also the decline of a certain territory, natural conditions should also be taken into account when planning and improving the development of local communities and local self-government units. Relief, as one of the basic natural conditions, should certainly be considered as an important development factor, but also as a limiting factor. The goal of this paper was to rank local self-government units of Jablanica and Pčinja district from the aspect of relief suitability. Based on the selected criteria, it was determined that the greatest relief suitability in the research area has the municipality of Bojnik, which cannot be considered as developed community. It is followed by the city of Leskovac, and municipality of Lebane, all from the Jablanica district. In the Pčinja first in rank by the relief suitability is the municipality of Preševo. All mentioned local self-government units should try to utilize this suitability much more in the future, and to improve their economic situation. The worst ranked are the municipalities of Trgovište, Bosilegrad and Crna Trava, where relief conditions together with demographic situation present serious limiting factor of development, with a little hope of greater improvement in near future.

This research considered general suitability of the relief. Next researches could address relief suitability from the point of view of certain economy branch or activity, such as agriculture, energy sector, in order to improve situation and economic development, not only in research area, but such research can be used in other parts of Serbia and the Balkan Peninsula.

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CHRONOLOGY OF THE URBAN EXPANSION OF BITOLA

DOI: https://doi.org/10.18509/GBP23183l
UDC: 911.375.1:930.24(497.784)

Maja Lazarevska[1]
Blagoja Markoski[2]
[1]Ministry of Labor and Social Policy of the Republic of **North Macedonia**
[2]University "St. Cyril and Methodius" Skopje, Faculty of Natural Sciences and Mathematics, Institute of Geography**, North Macedonia**

ABSTRACT

The spatial expansion and sprawling of cities in one particular territory is a condition that has greatly influenced the contemporary city and society.
The topic of this study is the genesis and the matrix of the spatial development of Bitola and determining the cause-effect factors and results.
The main thesis of the study suggests necessity for introducing a program-spatial matrix/paradigm in the development, so as to regulate the spatial expansion of the urban web. The program-spatial matrix is associated with the segment of planning, or the introduction of the normative structure.
The work methodology is based on a comparative analysis of the changes from a spatial-physical and a planning point of view. Due to the specifications of the region concerned, this study, in methodological sense, starts with providing documentary grounds, based on methods of collecting, documenting and analyzing the information found.
The conclusion of this study encourages the need for introducing a normative structure in the spatial development planning of cities in order to improve the spatial quality, the economic dynamics and the social cohesion.
The results of the study analyses ought to provide a clearer representation of the relations between the urban planning (spatial and general) and the space as well as the consequences of their implementation, or non-implementation.

Keywords: Bitola, spatial development, spatial expansion, urban development

INTRODUCTION

The topic of this study is the city of Bitola, a conglomerate and a development center, a pole with a great influence in the region and the country, its position in the region, , i.e. the spatial-physical context in the geographical surroundings, as a phenomenon with its own specific individual development. For better understanding of the issue, an analysis of the natural-geographic, social-geographic and economic-geographic features of the space has been made.
The spatial and urban city planning has been observed as a second segment. The city of Bitola is marked by nearly a hundred years of history of spatial planning.   The
spontaneous and non-regulated development of the urban web (up to 1929) has been replaced by a process of urban development and urban planning from 1929. The planning documents are the result of the social-political conditions that existed in that particular moment, as well as of the position and the significance of Bitola in that particular territory. From 1929 until today seven urban plans have been adopted, each of them covers the city integrally and defines its development as such. The plans have different content and

qualitative characteristics. They represent the atmosphere, the aspirations of the officials in charge and the actual relevant legislation, and their complementation does not usually indicate continuity in the planned development in relation to the existing situation.
In this study, different planning treatments are separately discussed in relation to the adopted plans, their decision on the boundaries of the urban-planning area as well as the city boundaries. This is done in order to obtain a more comprehensive analysis of the process of spatial and urban expansion of the city of Bitola.

GEOGRAPHICAL LOCATION AND ADMINISTRATIVE ORGANIZATION

Geographical location

The city of Bitola is located in the Pelagonia Valley, in the southwestern part of R. N. Macedonia between the latitudes of 41° 01' and 41° 03' N and longitudes of 21° 18' and 21° 22' E. Within its natural-geographic boundaries, the valley covers an area of about 4000 km^2, extending over the territories of our country and neighboring Greece. The Pelagonia Region itself covers a territory of 4,717 km^2 or 18.9% of the area of the Republic of North Macedonia. On the southern side, it borders the Republic of Greece and the Republic of Albania. The space is physically surrounded by the mountains Dautitsa from the north, Babuna from the northeast, Selechka Planina and Nidze from the east, Neredska Planina from the south and southwest, and the mountains Galichitsa, Plakenska and Busheva Planina from the west. [25][26].

Figure 1. Geographical location of the city of Bitola and the Pelagonia planning region in the Republic of Macedonia. Source: Markoski B. 2023

Administrative organization

Administratively, the territory of the Pelagonia Valley is covered by the Pelagonia Region (NUTS level 3) [2], as one of the eight non-administrative units - statistic regions which arouse by grouping the municipalities from lower rank in administrative units in the Republic of Macedonia. With the Law on Territorial Organization of Local Self-Government in the Republic of Macedonia, the territory of the Pelagonia Planning Region is organized into 9 units of local self-government-municipalities. Five of the abovementioned nine municipalities are based in a city (Bitola, Demir Hisar, Krushevo, Prilep and Resen), and four are based in a village (Krivogashtani, Mogila, Novaci and Dolneni), with the villages that belong to them territorially.

RESEARCH METHODOLOGY

The research process is based on several scientific methods. Due to the specifics of the problem area, the study, methodologically, includes the phase of providing a documentary ground (collecting, documenting and analyzing the obtained planning documents), i.e. the acquisition method. Original spatial and urban plans, cartographic and planning documents from state institutions, local self-government, the State Archive of the Republic of North Macedonia, the Archive of the City of Bitola, the Real Estate Cadastre Agency of the Republic of North Macedonia, planning houses, etc. are used as primary sources. Texts and comments from professional journals, publications, monographs and previously published scientific papers were used as secondary sources.
The data collected with the method of generalization and systematization have been processed, so that the data which have been obtained may be compared.
The basic method on which the research is based is the comparative analysis, which allows for the monitoring of the different conditions, that is, the changes from a spatial-physical and planning aspect. Analytical statistical methods and information methods were used for those needs. Tables, diagrams, etc. are used for clearer monitoring of the conditions.
The research results are presented as individual findings, as well as collectively. The conclusions and recommendations represent a synthesis of the research results and their comparison with the established hypotheses and basic theoretical postulates.

RESULTS

Chronology of the urban expansion of the city of Bitola

In the evolution of the urban development of Bitola, the following factors have a dominant influence: the socio-political environment, the dynamics of administrative and political changes, the role of the city of Bitola and its importance in relation to its surroundings, the legislative framework, the planning approach, the existing structure as a construction fund, and the conditions for the implementation of the planning decisions. From an administrative-territorial point of view, the city had its most significant role in the 19th century, when it became the seat of the Rumelian Vilayet, thus gaining the primacy of the capital city in the European part of Turkey. During this period, Bitola had developed craftsmanship, with strong commercial connections in the European centers. It is particularly significant that it also became a diplomatic center with 20 consulates opened in a certain period. Since 1864, the city of Bitola was the seat of the newly formed Bitola Vilayet, which covered a much smaller territory than before, that is, about 32,000 km^2, including territories of today's Greece and Albania. Since 1913, after the Balkan Wars, the city was occupied by the Serbs, within the Kingdom of Serbs, Croats, and Slovenes. In the period between the two world wars, Bitola lost its geo-strategic importance and the influence it had on Greece and Albania. In the period immediately before the First Balkan War, the vilayet had a population of over 1,000,000 inhabitants. [21][25]

In general, the urban development of Bitola can be analyzed through two periods: the pre-planning period until 1929 and the planning period from 1929 until today. In the pre-planning period and in the absence of spatial planning regulation, Bitola developed spontaneously and unsystematically. The planning period began after the First World War when the first urban ideas for the city were initiated. They were oriented towards de-Ottomanization, with ideas for transforming the existing city structure with elements of European cities. [14]

Chronological review of urban plans

Regulation Plan of the City of Bitola from 1929

The first planning document for the city of Bitola was drafted in 1929. The first cadastral records of the city were also prepared for the needs of this plan. There is only one copy of the Regulation plan of the city of Bitola, made on ozalid paper with a scale 1:5000, as a source document, which is kept in the Historical Archive in Bitola, i.e. the State Archives-Department of Bitola. For the purposes of this research, a document from the municipal administration was used, which is a certified copy "true to the original".

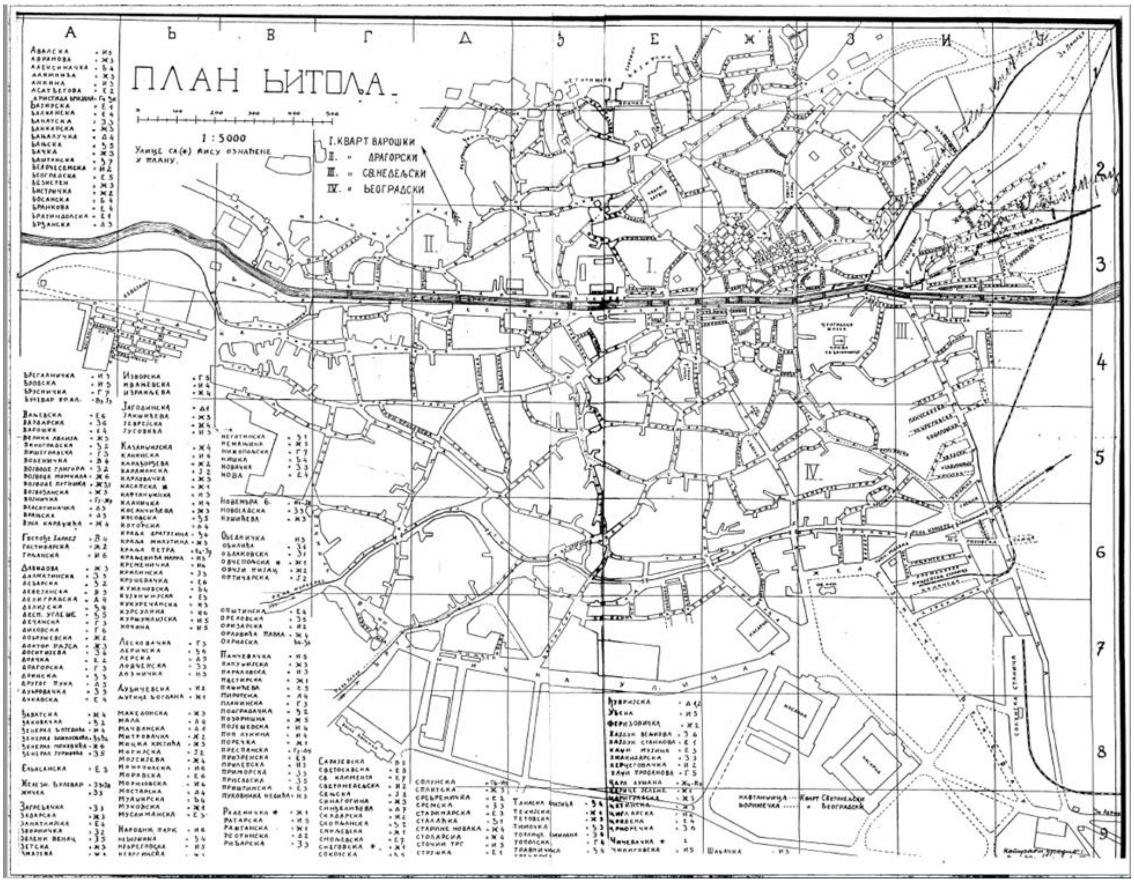

Figure 2. Regulation Plan from 1929. Source: municipality of Bitola [15]

In a socio-political context, the city was under Serbian occupation within the Kingdom of SCS. Between the two world wars, Bitola lost its geo-strategic importance and

influence on the territories in Greece and Albania. [25][21]. From the point of view of urban definition of the city web, it is significant that in this period the city started to be built and shaped systematically, exactly according to the plan of 1929. During this period, the city had a population of about 27,000 inhabitants and covered a territory of approximately 394.4 ha.
The legislative framework was defined with the document "Regulation on the construction profession in the liberated and annexed areas of the Kingdom of Serbia".

Directive Regulation Plan of Bitola from 1949

The first plan of the city of Bitola after the Second World War was developed by a group of authors at the Urban Institute of the People's Republic of Croatia in Zagreb, led by the architect Vlado Antolić, so it is included in the series "postwar author plans". There is no preserved documentation of this plan, except for a brief review in the professional journal "Architecture" no. 25-27 of 1949, - Zagreb, dedicated to urbanism in the People’s Republic of Macedonia [8]. The graphical display shown below is from the text "Urban planning in Macedonia in the last fifty years" from the jubilee anthology "50 years of the Faculty of Architecture" from 1999. In the planning solution, Antolić shows restraint in his concept, with maximum respect for the construction fund and plans minimal interventions in the city web. He places the emphasis on mass construction in the peripheral parts of the city. He instructs that it is necessary to intervene carefully in the established central city areas by developing detailed urban plans.[24] The planning area obtained by approximating and applying the boundaries to the cadastral records is approximately 720 ha. In that period, the city had a population of 30,761 inhabitants.

Figure 3. Directive Regulation Plan of Bitola, 1949 [10].

General Urban Plan of Bitola from 1958

In 1958 the General Urban Plan of Bitola was developed in two stages: conceptual study and conceptual project. The study was made in the “General Plan” design studio from Belgrade, under the supervision of eng. arch. D. Momcilović. Due to a series of expert comments made by the Republic Revision Commission, especially on the traffic solution, zoning and population density, this plan was not officially adopted by the City People's Committee at that time. Even though it was not adopted, the construction in the period 1958-1965 took place according to that plan.[8]

Basic urban plan from 1968

In 1965, the Assembly of the municipality of Bitola adopted the "Decision on the construction and organization of the city of Bitola", which replaces the urban plan, and in June 1966 it adopts the "Urban Study" prepared in the Institute of Urbanism and Architecture - Bitola. One of the reasons for establishing this Institute at the beginning of 1962 was to engage it in the development of a basic urban plan, in accordance with the first Law on Urban Planning from 1958.

A common feature of the previous planning documents is that the primary emphasis was given to the residential zones, while the rest of the functional zones were not dealt with at such a great length. They did not develop the plans multidisciplinarily, with the participation of sector studies, but the development concept was guided by the intuitive insights of the authors. The processing method was impractical due to the fact that they included more details than a basic urban plan was supposed to have, which in practice turned out to be more restrictive than simply directional. Another unifying element for the previous plans is the planning approach which did not respect the existing city structure and its heritage at all, which is especially seen in the planned traffic concept.

Based on a study from 1966, the Institute from Bitola in cooperation with the Institute for Urban Planning and Housing-Communal Technology of FRM - Skopje, prepared the Basic Urban Plan of Bitola. The plan was adopted by the Assembly of the municipality in February 1968. The Study and the Plan were developed under the supervision of the architects Gogo Vidimche, Dimitar Dimitrovski and Kiril Stojanovski from the Institute of Urbanism and Architecture - Bitola. When it comes to legislative regulations, the Law on Regional, Spatial and Urban Planning was in force ("Official Gazette of FRM" no. 7/65 and 16/67).

The plan was developed for a planning period of 20 years, that is, 30 years after the adoption of the urban study from 1966. In 1961 the city had 49,001 inhabitants, with an average standard of 8m of net residential area per inhabitant. The estimation was that by 1996, 95,000 inhabitants would live in the inner city area and another 13,000 in the suburbs of Gorno Orizari and Bukovski Livadi, or a total of 108,000 within the wider urban area.

The traffic solution, made without a preliminary study, does not respect the existing street network. Three entry-exit points of the city are stipulated. These transit routes limit the inner construction area.

The plan provides a dedicated treatment of seven functional zones (housing, work, greenery, sports and recreation, reserves for post-plan construction, special-purpose grounds, agricultural and free areas for off-site greenery).

Compositionally, the plan stipulates 60-80 m wide areas with a high intensity of construction, along with the primary traffic routes.

The urban area is treated as: 750.99 ha of inner construction area; 1,641.80 ha of wider construction area and 2,392.79 ha of area within the limits of urban development. It must be noted that the analyzes were made with the total area in the analytical territory of the city, which is 1,250 ha.

The plan determines three stages of implementation, which are accompanied by fiscal projections for their implementation.

A very low percentage of the planned construction was accomplished in the first stage. This is greatly due to the traffic solution and the disregard for the existing urban web, as well as the construction of the areas along the roads, which was prevented because the valorization of the construction fund that was supposed to be demolished never happened. This led to a decision to revise the planning solution.

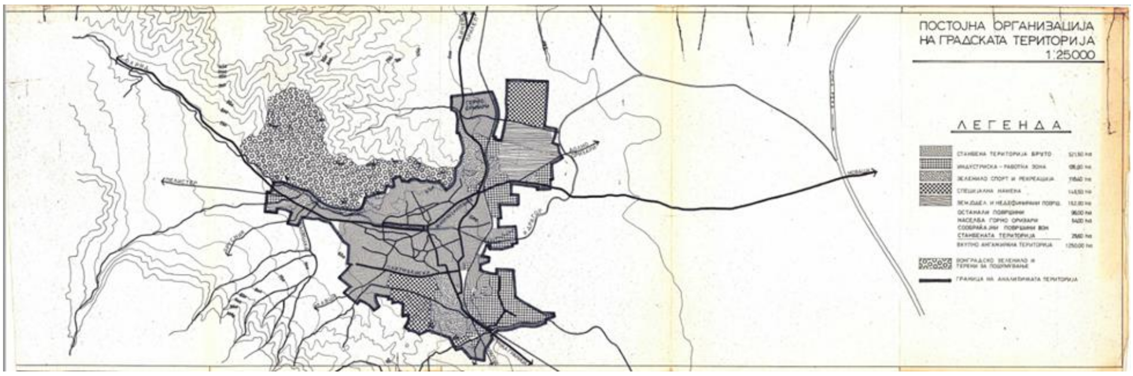

Figure 4. Existing organization of the city territory (BUP 1978 – documentary grounds) from 1978. Source: municipality of Bitola [7]

It should be pointed out that in the period from after the war until 1976, or in a time frame of thirty years, the city was exposed to a strong process of urbanization, like other urban centers in the country, and as such it could not be controlled, directed and organized in an optimal framework. During this period, illegal residential construction is realized in a higher percentage than the legal one, which can be seen from the ratio of 106 ha versus 87 ha of construction of new areas. At the end of the period of the first stage of the implementation of the plan, the sector study showed that 25% of the entire housing fund was illegal construction.[7]

Basic Urban Plan - Amendments from 1978

In the period from 1968-1975, socio-economic and commercial trends imposed a need for amendments to the Basic Urban Plan of Bitola from 1968. The planning document was adopted on April 3, 1978 with a planning period until 2000. The amendments were made in the Institute for Urban Planning and Design-Bitola, with the participation of the Directorate for Spatial Planning Ohrid-Skopje and a specially formed team under the supervision of the architect Kiril Stojanovski, an authorized independent designer from the Institute, and a consulting group led by prof. Borko Novaković PhD from the Faculty of Architecture in Belgrade. These amendments were made simultaneously with the first Spatial Plan of the municipality of Bitola. The need to create a spatial plan proceeds from the new Law on Spatial and Urban Planning ("Official Gazette of FRM" No. 15/73). The spatial plan itself indicates the need to review the Basic Urban Plan in terms of optimization of the further development of the city, and, at the same time, it treats the phenomena and processes in a wider regional context in which Bitola acquires a more prominent position as a regional hot spot of development.

"The amendments to the BUP from 1978 were made based on the principle of urban zoning by determining the directions of the spatial development of the basic functional zones and connecting them into a single and compact city organism." (Third amendments to the GUP of Bitola - text) [7]

The plan is based on several important planning principles: the BUP is a spatial projection of the long-term socio-economic development of the city with maximum respect for the natural and man-made environment and material opportunities; the BUP is a contract and agreement of all subjects, users of the plan and citizens of Bitola; the planning is a system of plans that influence and complement each other, which requires the implementation of a vertical and horizontal planning system; the urban planning is a unity of the procedure for the preparation and implementation of the plan, which requires a continuous and permanent process of planning and tracking the changes; the planning as a process of tracking, analyzing and predicting the overall development requires scientific and interdisciplinary considerations; in the long-term development of planning, mid-term stages are introduced to ensure the flexibility and implementation of the long-term plan; the amendments to the plan should be understood as spatial insights for the long-term development of the city that are changed, that is, replaced, in a shorter time than the planning period. The last principle is perhaps the most important essential assumption of the work methodology and the determination of what the usability and applicability of the plan will be, while the plan must follow the development processes of the city and its planning, with a critical attitude towards the previous development, condition, immediate and planned development.

The plan deals with three levels of observations, analyzes and syntheses, as a basis for planning the development, usage and organization of the space. The first level is within the framework of the spatial-functional organization of the country as a territory, directly conditioned by the position of the city in the overall social-political and spatial-functional organization of FRM. The second level is the city of Bitola in the role of a regional center. The third level is the city as a whole, its internal organization and connection with the environment.

In relation to the concept of spatial organization and establishing a long-term concept for spatial development, the emphasis is placed on integration and planned organization of the development activities. Due to such development aspirations and the importance of the city in the regional context, the plan stipulates an inner and wider urban area.

In the wider area of the city, the creation of a new metropolitan structure with a radius of 7km is stipulated. With the plan to satisfy the assumptions for development, two planning periods are given, until 1985 and long-term until the year of 2000 with the following planning guidelines: - the planning area of 1250 ha increases to about 2300 ha of analytical territory (or 2440 ha in the graphical displays) approximately allocating one-third for housing, work and recreation respectively; - the space outside the city territory is treated as a wider metropolitan area, in terms of organizing the suburban villages and in terms of the way in which the populated territory is used; - the expansion of the city with a purely residential structure shall be carried out in the unoccupied terrains in the west, and the residential-working structure in the north and south, thus achieving the most rational ratio in the quantitative usage of the urban space. The plan protects the fertile agricultural area to the east.

In terms of demographic indicators, in 1975, when the amendments to the BUP began, Bitola had 73,400 inhabitants, with an average density of 58.7 inh/ha. The housing standard of net housing area was 11.9 m^2 per inhabitant. During this period, migration movements from rural areas to the city were strongly expressed. The spatial plan stipulates other urban centers in the municipality in the long-term development. Their function would be to reduce the pressure of the population on the city and ensure a rational spatial organization of the entire space in the municipality. The plan makes a projection of 110,000 inhabitants for the end of the planning period in 2000 within the limits of the planning area of the city, based on the findings of the research of the Spatial Plan of the city. The plan stipulates an increase in the housing standard, that is, the average net housing area to be 18m^2 per inhabitant. In order to meet this standard, the construction of new housing facilities with an area of 1,317,600 m^2 is planned, which is twice as much as the existing housing fund. The planned growth of newly built apartments per 1000 inhabitants tends to approach the parameter 10 on an annual level, respecting the recommendations of the ECE – The United Nations Economic Commission for Europe. "The dynamics of construction of about 10 apartments per 1000 inhabitants annually is considered to meet the needs of the natural and mechanical population growth of the developing countries." Among the provisions for regulating the planning aspects of housing, it is interesting to point out that the plan advises that the sales value of 1m2 of residential area should approach the amount of the average monthly personal income. The total area intended for housing within the planning area is 610 ha.

The analyzes indicate insufficient capacity of the existing city center for the functions of importance for the city and the region, so the plan stipulates an increase in the area for public functions in the space of the wider central city area. The plan also stipulates a hierarchical system of centers, corresponding to the zones of functional organization, to meet the needs of the planned capacity of 110,000 inhabitants in the city, i.e. 130,000 in the metropolitan area. The total area intended for central public functions is 134 ha.

The working area is planned to be 503 ha, which represents a significant increase compared to the existing situation at the time. The development zones are planned with the necessary accompanying infrastructure facilities and functional equipment.

Regarding the traffic concept, the BUP is based on the following settings: - retention of the major roads along the sides of the city core; - establishing functional connections between the industrial zone, the housing areas and the central area of the city; - a favorable connection with the external and suburban network of roads; -removing the intense motor traffic from the city center; -minimum intervention in the old part of the city in order to ensure the optimal conditions for the preservation of the architectural heritage and the old city bazaar.

The green areas have a significant role in the plan. A norm of 16.7 m^2/inhabitant was achieved, of which 7.59 m^2/inhabitant is city greenery, while 9.11 m^2/inhabitant is regional greenery. The size of the planned green areas satisfies the basic functions, but their spatial distribution in the overall structure of the city is not even. Except for the city park, which is located closest to the central parts of the city, all other parks are located peripherally. The plan stipulates off-site greenery by using the potentials that the city has on the southwest side of the slopes of Pelister, as well as on the north side of the slopes of the Oblakovno-snegovski massif. For this type of green areas, 1650 ha were provided in the immediate vicinity of the city, which represents a capacity of 150 m^2/inhabitant. The zone for greenery, sports and recreation covers an area of 592 ha.

This plan too provides guidelines for gradual implementation within the two planning periods, with specified concrete segments for implementation.[7]

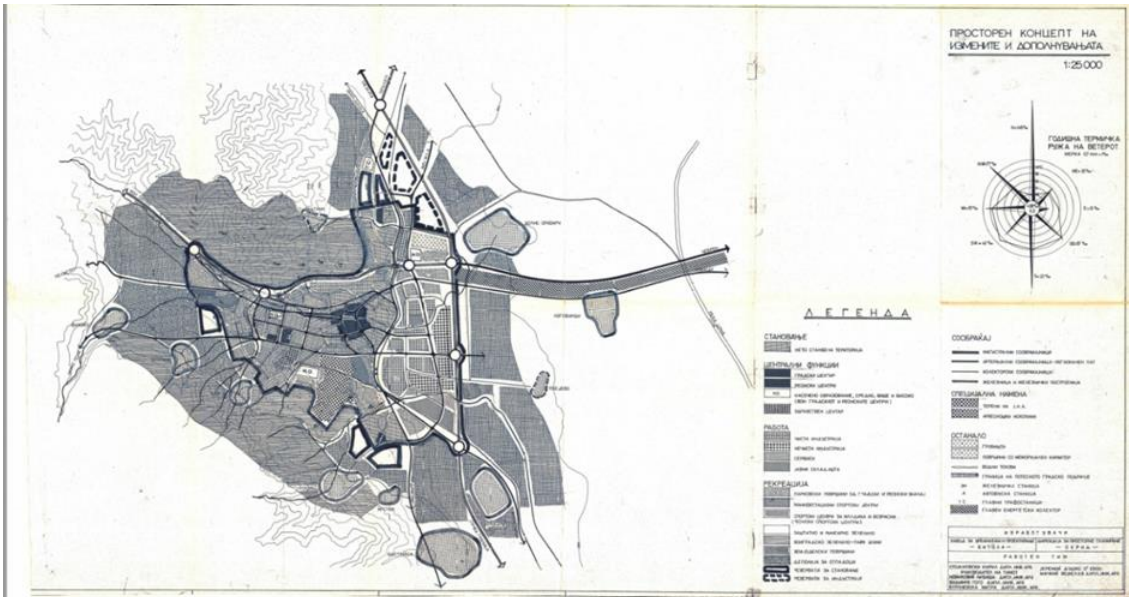

Figure 5. The spatial concept of the amendments, BUP 1978. Source: municipality of Bitola [7].

Basic Urban Plan of the city of Bitola - second major amendments

The second major amendments to the Basic Urban Plan of the city of Bitola date from February 16, 1990 and represent the sixth planning document which deals with the city integrally. This plan was developed at the Institute for Urban Planning and Design, Bitola, by a specially formed team under the supervision of Ljubisa Novaković, B.Sc. eng. arch., an authorized independent designer in the Institute, and a consulting team under the supervision of prof. Borko Novaković from the Faculty of Architecture in Belgrade. The plan essentially represents an analysis of the implementation of the first stage of the previous amendments (in the period 1976-1985) and is a guideline for the implementation in the next period until the year of 2000.

This plan maintains the development guidelines conceptualized by the previous plan, and provides continuity to the established functional zones and their connection within the city agglomerate and beyond it. The urban area is rounded to 2,440 ha in the text of the plan, while graphically it covers an area of 2,600 ha. [8]

General Urban Plan of Bitola from 1999 - third major amendments

After the adoption of the previous plan in 1990 and the second major amendments to the BUP of Bitola, the processes which represent a negation of the previous social-political and economic system start. A substantial change is taking place in the designation of the proprietary rights holder, as well as in the transformation of the economy in general in order to enable it to function in market operating conditions. These altered socio-economic conditions impose a need to reconsider the attitudes and the development guidelines of the existing BUP. The plan was started in 1995, with a planning period for development of 15 years, i.e. until 2010.

Demographic analyzes based on the results of the 1994 census show a large decrease in the total number of inhabitants in the municipality and the city. Namely, according to the predictions of the BUP, around 94,000 inhabitants were supposed to live in the city in 1994, but the census recorded 79,456 inhabitants. This large trend of population decline is due to the high rate of migrations and the drastically decreased natural population growth. Based on the results of the census and the analyzes (until the end of the planning period), the plan makes two different predictions for the number of inhabitants, a pessimistic one and an optimistic one, A mean prediction, which estimates the number of inhabitants to be 82,400 by the end of 2000, 84,800 by the end of 2005 and 87,500 by the end of the planning period in 2010, is accepted as a plausible prediction.

The analytical review of the economy reflects pessimistic development trends during the period of preparation of the plan. The process of centralization of the departments for analysis and a plan at the Secretariats for the economy from the municipal level to the central-state level caused an interruption in the monitoring of the situation in the economy and planning. This was directly reflected on the prediction of the development of the economy and on economic planning in general. The development predictions of the previous BUP were realized in the first decade of its implementation, but they were not within the predicted frameworks in the period from 1986-1990. This was a period marked by a state of stagnation and decline, which was ascertained by the Second Amendments to the BUP from 1990. The conditions noted in the period 1991-1995 show that the development planned by the BUP was unfeasible, with economic flows that are contrary to those predicted. The new GUP examines the aspects for the development of the economy and bases them on the following circumstances: - the city as the center of the largest agrarian area in the country; - the city as a center with great energy potentials; - existing development of industrial facilities and -a solid infrastructure for their realization. One of the goals of this GUP is the creation of a work zone which, through the projection of spatial distribution and functional connectivity, will not represent a barrier to implementation.

The planning solution of these third major amendments retains the concept of the previous plan, respecting the evolutionary line of the development of the urban web. The planning continuity is practically based on the plan from 1978, which is a key strategic document that determines the development direction of the city agglomerate. The following plans fully accept it conceptually and make small corrections in certain segments in order to comply with the current needs and trends, as well as the existing situation. The plan abandons the strict zoning of the city by means of strictly differentiated basic functional zones and begins a process of interweaving different functions and uses of the land, to the extent that it will not disturb or threaten the basic purpose and function.

The urban area is taken from the previous plan, but with certain cuts: the routes of the M5 main roads and the planned branch to Medjitlija are excluded from the area; most of the off-site greenery is excluded; areas for planned expansion (working and residential zone), which makes the total area to be 2,245 ha.

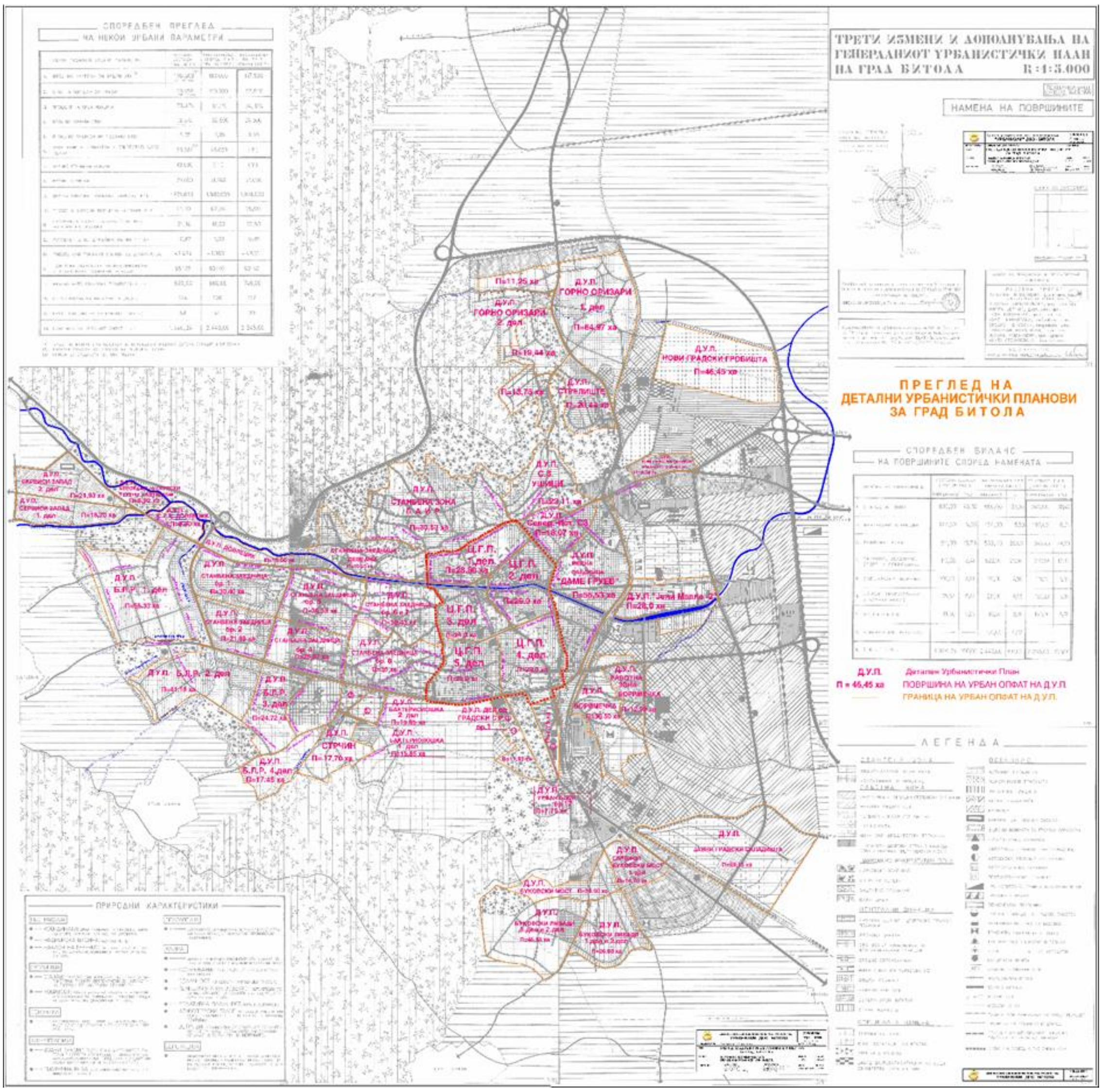

Figure 6. General Urban Plan from 1999 - graphical display of land use with an overview of detailed urban plans. Source: municipality of Bitola [8].

Regarding the residential zone, it should be noted that a high percentage of the demographic predictions made by the previous plan were not realized. Instead of the planned 110,000 inhabitants in 2000, the city had 74,550 inhabitants in 2002. This plan estimates that there will be 87,000 inhabitants by the end of the planning period in 2010. Despite the large decline in the planned number of inhabitants with the current plan and the planning of a smaller number with the new plan, the residential zone does not decrease, but increases from 630ha to 749ha. About 89ha of clusters of illegally constructed residential buildings are included in the expansion. The planned average net density is 117 inh/ha, and the gross at the city area level is 39 inh/ha. The housing standard has increased significantly, with the net usable area per inhabitant in 1995 being 21.04 m^2, which is expected to grow to 23 m^2 by the end of the planning period. Quantitatively, the housing capacity meets and exceeds the needs of the city, and the planning of this fund is aimed at qualitative improvement of the standard of housing in general.

Similar to the situation in the residential zone, the planned growth was also not achieved in the working zone, in terms of the realization of the areas for this purpose. With the

previous plan, the working zone had an area of about 500 ha. The 1995 inventory showed that out of those 500 ha only an area of 210 ha was realized. Despite the large reserves of planned area for the economy, the plan again provides for an increase in the area of the working zone to 643.45 ha. The expansion is mostly due to the zone for dirty industry which is planned without realistic assumptions for a specific user or users of the space, but in order to reserve an area for the appropriate purpose and to protect the land from illegal construction.
Unlike the residential and working zone, the plan shows a different development trend in the park and recreational zone. The new GUP reduces the planned 622 ha for greenery, sports and recreation (allocated with the previous BUP) to 276.88 ha. This difference of about 347 ha is actually not so drastically expressed in terms of the areas for the realization of the abovementioned contents, but primarily refers to the protective belts of the traffic corridors which are excluded from the plan area.[8]

DISCUSSION-ANALYSIS OF THE URBAN EXPANSION OF BITOLA

The development line of the territorial expansion of the city of Bitola is a reflection of the aggregate reaction of several variables. In the wide range of factors of influence, the dominant position is taken by the socio-political environment with a pronounced dynamics of change, the role of the city in the administrative-economic-functional context and its significance at the level of a certain territory, the legislative framework, the planning approach, the existing structure as a construction fund and conditions for implementation of the planning solutions. [4][21]

Analysis of the fluctuation of the population number

Considering the demographic analyses from the beginning of the twentieth century, it can be seen that the city goes through periods of different intensity of population fluctuation. The most pronounced downward trend was at the beginning of the last century, where, in a period of two decades, there was a decrease of the city population by 55%, from about 60,000 to 27,000 inhabitants. This is the result of a period of great social turbulence, starting with the Ilinden Uprising, the Young Turk Revolution, the Balkan Wars, the First World War, after which many changes took place in the wider socio-political situation, which strongly reflected on the city of Bitola. This is followed by a period of growth in the population number, until the Second World War, when, consequently, the number of inhabitants decreases again. [21]
In the post-war period, a trend of population growth begins, especially pronounced in the fifties and sixties (more than 30%), continuing with a more moderate rate of 20% in the seventies and 7% in the eighties, when the stagnation in the development processes in the city is already begun.
In the period that follows, the city enters a negative trend of population growth.
According to the census of 1994, a large decrease in the total number of inhabitants in the former municipality and the city was ascertained, which is illustrated in the analytical part of the plan. According to the predictions in the PP of the former municipality of Bitola, at the end of 1990, about 158,000 people were supposed to live in the municipality and about 94,000 in the city. With linear interpolation in the predictions between 1990 and 2000, in the middle of the last decade of this century (1994-1995) around 169,000 were supposed to live in the municipality, and around 102,000 in the city. The census of June 20, 1994 denied these two predictions, with the municipality having a total of 108,203 inhabitants (60,797 fewer than the predictions), and the city together with Gorno Orizari

79,456 inhabitants (22,544 fewer than the predictions). (GUP text part III Demographic development). Due to the previous findings, the GUP from 1999 projects that in 2010 the city will have 87,500 inhabitants, which did not happen (12,950 less inhabitants according to the 2002 census, and 18,213 less than the 2022 census).
Looking at the final population figures in the period from 1900-2022, the city recorded a population growth of only 15.48% or 1.15 times in 120 years, and 2.57 times in the period 1921-2022 (the period of planned development).

Table 1. Changes in the number of the population in the city of Bitola in the censuses from 1900 to 2002.

year	1900	1910	1921	1937	1948	1953	1961	1971	1981	1991	2002	2022
Number of population	60.000	52.729	27.000	33.024	30.761	37.561	49.001	65.035	78.507	84.002	74.550	69.287
%		12,13↓	48,8↓	22,31↑	6,85↓	12,2↑	30,5↑	32,7↑	20,7↑	7↑	11,2↓	↓7,1

*Sources of data: [4, 5, 6, 7, 9, 16, 17, 18, 21]

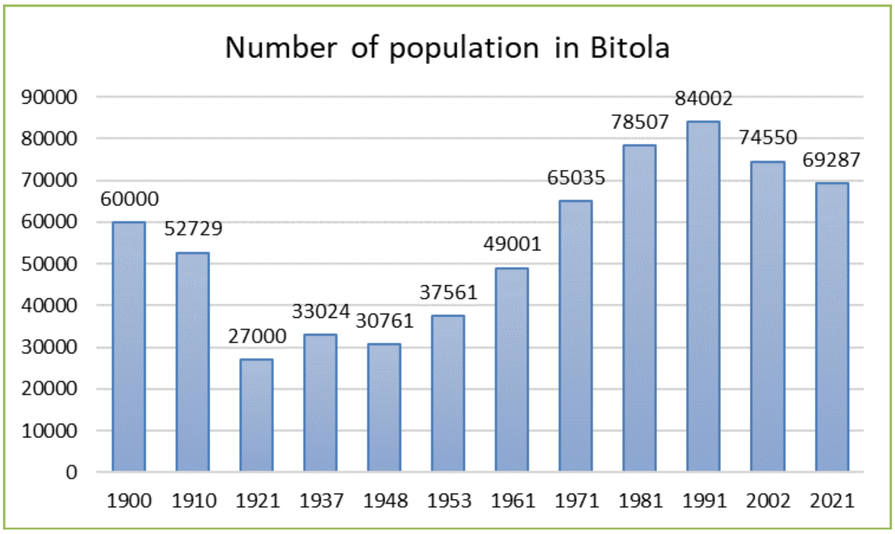

Figure 7. Changes in the number of the population in the city of Bitola in the censuses from 1900 to 2002.

Analysis of the territorial expansion of the city

The analysis of the territorial expansion of the city is made with the method of comparison- by overlapping the surfaces of urban areas of the urban plans. Based on that, a documentation basis was created, as a foundation for the development of urban plans. The obtained measurements are plan-by-plan and integrally discussed.

Table 2. Preview of surfaces of urban areas of urban plans

Urban Plan	Regulation Plan 1929	Directive Regulation Plan of Bitola 1949	Basic Urban Plan 1968	Basic Urban Plan – Amendments 1978	Basic Urban Plan – second major amendments 1990	General Urban Plan 1999
Surface area (ha)	394.4	720	1.250	2.440 (graphic)	2.600 (graphic)	2.245
Surface increase (ha and %)		325,6 (82,56%) ↑	530 (73,61%) ↑	1.190 (95,2%)↑	160 (6,56%)↑	-355 (-13.65%)↓

Source: [7, 8, 10, 15]

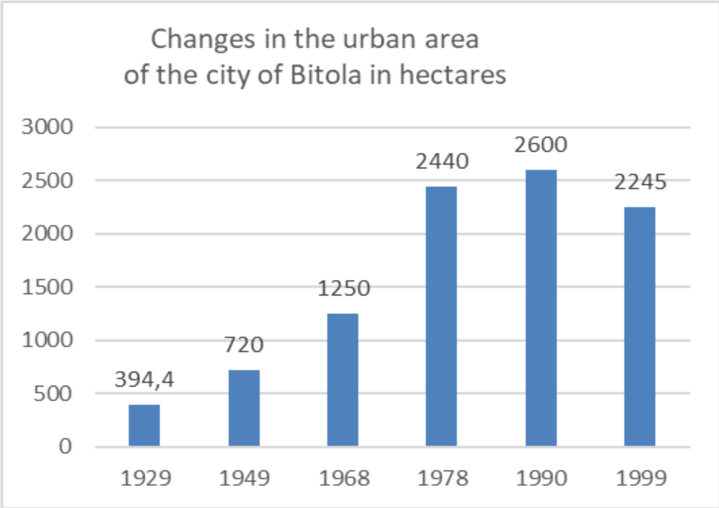

Figure 8. Changes in the territorial expansion of the city of Bitola in the period from 1929 to 2021.

Regulation Plan 1929. The boundaries of the city are about 394.4ha in the plan from 1929. [15]

Directive Regulation Plan from 1949. With this first post-war planning document, an increase in the city territory is planned. The expansion is emphasized in the peripheral parts, with a tendency to respect the existing city structures of the old core. The boundary of the city's area was obtained by applying, that is, marking the foundation of the plan and it is approximately 720ha, which represents an increase of 82.56% compared to the boundary of the previous plan. [10] [24]

Basic Urban Plan from 1968. The plan deals with an inner construction area of 750.99ha; a wider construction area of 1,641.80ha and an area within the boundaries of the urban area of 2,392.79 ha. However, the actual analytical territory of the city is 1,250ha, based on which all the analyses were made. The plan was drafted for a planning period of 20 years. The records from the documentation basis of the Basic Urban Plan – Amendments from 1978 were used for the analyses. The plan stipulates an increase of the city boundaries by 1.74 times or 73.61%. The plan also stipulates large reserve areas for the future expansion of the city which are not taken into account by the analytical calculations.[7]

Basic Urban Plan - Amendments from 1978. The plan uses a comprehensive approach, with the creation of a spatial plan with relevant sector studies. The new planning concept expands the city area greatly. The plan stipulates the expansion of the purely residential structure to be carried out in the terrain to the west, the residential-working structure to the north and south, while protecting the fertile agricultural area to the east. Namely, in the wider area of the city, the creation of a new metropolitan structure with a radius of 7 km is stipulated. The plan (in order to satisfy the assumptions for development) provides two planning periods, until 1985 and long-term until 2000, planning a city territory twice its size (from 1,250 ha it increases to about 2,300 ha analytical territory, i.e. 2,440 ha in the graphical displays). [7]

Basic Urban Plan of the city of Bitola - Amendments from 1990 (second major amendments). The plan itself is actually an analysis of the implementation of the first stage of the previous amendments and is a guideline for the implementation in the next period until the year of 2000. This plan retains the development guidelines conceptualized by the previous plan and provides continuity to the established functional zones and their connection within the city agglomerate and beyond it. The urban area is rounded to 2,44

0ha in the text of the plan, while graphically it covers an area of 2,600 ha, so there is an insignificant increase of 6.56%, that is, it can be considered that it retains the city boundaries determined by the previous plan. [8]

General Urban Plan from 1999. The planning solution follows the established planning concept, but considering the negative demographic trends, optimizes the city boundaries and, with the purpose of rational land use, a smaller planning area is planned for the first time. The city is territorially narrowed from the planned 2,600 ha to 2,245 ha, which represents a decrease of 13.65%. [8]

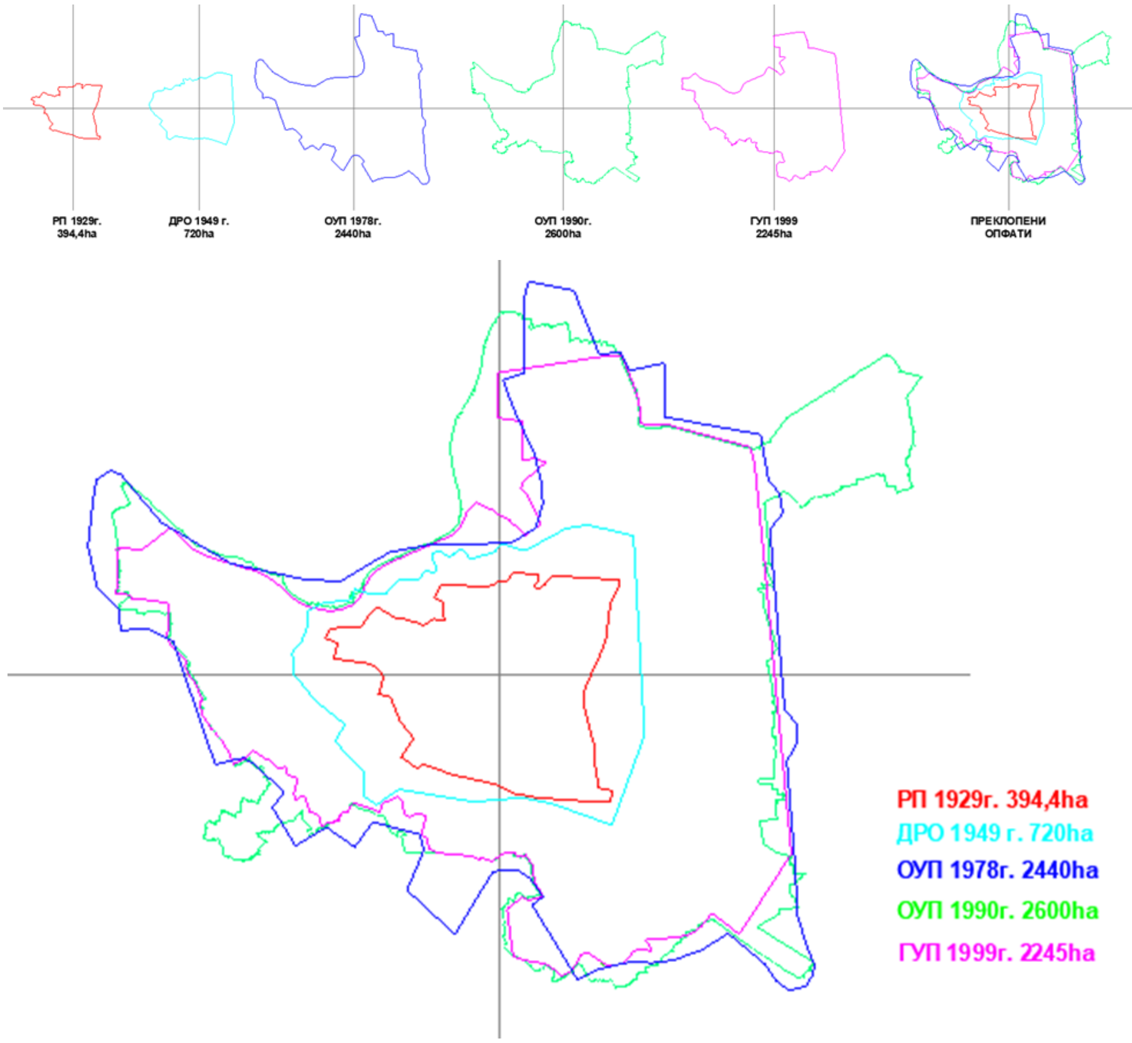

Figure 9. Overlap of planning areas of adopted plans
Source: author [7][8][10][15]

CONCLUSION

Having in mind all elaborations, it can be perceived that the development line of the city of Bitola, as a result of the planned treatment, begins in 1929 with the Regulation Plan which plans the city an area of 394,4ha, which is almost doubled (82.56%) in a period of two decades with the Directive Regulation Plan. The trend of increasing the city area continues at a similar rate (73.61%) in the next Basic Urban Plan, with a time span of two decades (1968). This is then followed by the greatest territorial expansion, with an increase of 92, 5% of the city area, in a period of only one decade (Basic Urban Plan –

Amendments from 1978). With the next plan from 1988 (Basic Urban Plan - Second Amendments) the growth rate of the city territory is declined, predicting a small increase of 6.56%, and with the last adopted General Urban Plan from 1999 the growth rate has a negative value for the first time and the territory of the city decreases by 16.35%. Following the figures within the period of planned development (94 years to date) the area of the city increases from 394.4ha to 2,245ha or by 5.7 times.
Taking into account the demographic analyses and the increase in the number of inhabitants of the city within the same planning period, it is ascertained that the population has grown by 1.15 times, while the territory of the city has grown by 5.7 times. This means that there is a huge disproportion of growth between the population and the territory of the city of Bitola.
These data, which express the great growth rate of the boundaries of the city of Bitola, inevitably raise the issue of sustainable development policy, rational land use and, of course, protection of agricultural land and forests.
The elapsed time, during which the transition process continuously has been taking place, has brought about major economic changes which generate structural changes in the development plans of Bitola. The dynamics of this process has implications for the creation of new spatial relationships and conditions the need for planned articulation of the city space. The alteration of spatial constellations necessarily requires the evaluation of the urbanization process, the territorial and morphological development of the city, the re-examination of urban processes, the spatial consolidation and the establishment of a consistent urban model. Two decades after the adoption of the current GUP, in the "Analysis of the degree and manner of implementation and realization of the urban plans in the area of the municipality of Bitola", prepared by the Commission for Urban Planning, established by the mayor of the municipality of Bitola, from December 20, it is stated that the General Urban Plan has 68% realization, in accordance with the adopted detailed urban plans within the boundaries of the GUP and it is stated that "it is in contradiction with the goals for sustainable development and other global development documents in the field of urban planning..." (Analysis of the degree and manner of implementation and realization of urban plans in the area of the municipality of Bitola (2021): p. 3).
Due to the complex structure involving different segments and their interrelations, there is a need of all-inclusive analysis. In this way, we can obtain an integral representation of the occurrence and its meaning in general. The research has to provide the mutual relations, the conflict points and the negative effects of the urban expansion of the city web, at the expense of the elements for sustainable development and rational land use, protection of agricultural land and forests. When determining the proper program-spatial matrix as a tool for spatial planning, apart from all aspects of the existing situation, the inventory, the relations in the urban web, the relations between the urban and rural sections, the needs, the spheres of interest, the possibilities for alternative and multipurpose use, as well as the conflict points in using the land, the developing line should be based on the strategic theses of the European Union for spatial planning. They are mainly oriented towards polycentric and balanced spatial development, integration of the urban and rural environments, territorial integration in the international functional regions, providing competition in regions based on strong local economies, improving communication infrastructure between the population, the community and the economy. This can be done if all aspects of protecting and enhancing the environment and the cultural goods are taken into account. [1][4][5][6][7][8][9][15][16][17][18] [21][22][23]

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ECONOMIC POWER AND STRUCTURE OF STYRIA IN THE MIRROR OF THE TAX POWER PER CAPITA RATIO IN TIMES OF COVID-19

DOI: https://doi.org/10.18509/GBP23203g
UDC: 911.7:616.9]:[352:336.14(436)

Josef Gspurning
Institute for Geography and Regional Sciences, University of Graz, Heinrichstrasse 36, 8010 Graz, **Austria**

ABSTRACT

Especially in times when unpredictable events such as pandemics strain both the economy and society to their limits, knowledge about the current state of public welfare or about the financial situation of the associated spatial units is particularly interesting. In this context, the per capita tax performance in the administrative units (tax power per capita ratio, hereafter STKKQ) is considered a very reliable indicator for estimating the economic performance of a municipality, especially since it is composed, on the one hand, of the municipal taxes and, on the other hand, of the so-called "shared public income" of the state of Austria; this allows not only the nationwide comparison but also the annual review of the development of this value. In the present paper, the STKKQ on the basis of municipalities (which corresponds to the smallest administrative unit for which statistical ratios are available at mostly annual intervals) was used to examine a number of focal points: First, not least in view of the numerous governmental programs during the COVID-19 pandemic, the temporal development of the indicator in the years until 2021 was examined before the distribution of the STKKQ value in the province of Styria was investigated via the quantification of the global and local autocorrelation. Finally, a significant spatial correlation between the STKKQ and certain socio-economic parameters (population size, number of jobs in the Styrian municipalities, high tourism share, ...) was tried to be proven.

Keywords: community budget, fiscal capability, spatial analysis, Styria

INTRODUCTION

Despite its relatively long history, the Central Places Model - although repeatedly adapted to the changed social, economic and political framework conditions - still serves today as a basis for spatial planning decision-making processes [1], [2] or [3]. The latter, for example, opines "Central places are not the products of chance, but the result of a long-term market economy process."

This emphasis on the market economy suggests that different degrees of economic prosperity can be held responsible for a differentiation of space into economically stronger and economically weaker regions (in a sense central and peripheral spaces). From the point of view of politics and society, the logical reaction to this process is the endeavor to compensate for recognized deficits and in this way to ensure - within the framework of the existing possibilities - an optimal development of the area and thus to effectively counteract negative tendencies such as out-migration, aging of the local population, thinning out of the infrastructure, etc. The development of the area as a whole is a matter of course.

This is also true for the Austrian province of Styria, where, in addition to the rural, peripheral areas and the former industrial areas in Upper Styria (mostly areas of out-migration in recent decades), there is also the so-called Styrian Central Area, which is growing steadily in terms of population and importance [4]. Especially the number of inhabitants is important for the Styrian municipalities for several reasons, since the number of political representatives depends on the number of inhabitants and decreases accordingly when the number of inhabitants decreases. Excessive out-migration thus also has an impact on the results in supra-regional elections, as the respective region thus loses influence in future development policy votes. However, the decrease in population also has fiscal effects, especially since this also reduces the flow of money back to the municipalities from the federal and state governments and thus also tends to reduce the municipalities' income from the so-called fiscal equalization system. In order to counteract this development and to better equip the province administratively for the future, the municipalities in Styria were reduced from 539 to 287 on Jan. 1, 2015. As a result of this reform, municipalities with fewer than 500 inhabitants have largely disappeared from the map, which should create efficient municipalities throughout Styria [5] or [6]. From the above, the need for a parameter that makes all the effects described directly or indirectly measurable or comparable and, moreover, makes these results comparable with each other over a longer period of time becomes understandable; since only a few economic statistical data are made available for Austrian municipalities on an annual basis (such as data on unemployment or on supply and demand in the tourism sector), the portfolio of methods for the spatiotemporal analysis of this phenomenon is relatively manageable. For this reason, the approach presented here attempts to use the informative value of the parameter tax power per capita ratio (STKKQ), which has been consistently reported since 1999, to assess the economic position of Styrian municipalities. This seems plausible insofar as a high STKKQ presupposes at least a certain size of municipality coupled with a high economic power. Thus, a municipality with a high STKKQ has an economically and/or politically superior position compared to the other administrative units [7]. In detail, the following questions arise from the problem just explained:

- How has the tax power per capita ratio in Styrian municipalities developed as of 2015? What impact did the COVID-19 pandemic have?
- Can development or spatial patterns of the tax power per capita ratio be identified on the basis of time series data?
- Are there clusters of municipalities with the same/similar tax power in Styria and where are they located?
- What other parameters influence the tax power per capita ratio or how do they affect the tax power per capita ratio?

BASIC CONSIDERATIONS

Characteristic and meaning of the tax power per capita ratio

In official Austrian statistics, the STKKQ is simply referred to as "tax revenue per capita" or as "taxes and revenue shares of municipalities per capita (in €)" [8]. A somewhat more detailed definition is provided by the Provincial Statistics of Styria: "The tax revenue per capita of a municipality is the sum of the exclusive municipal taxes, which are again used in the municipality's own sphere of activity, the revenue shares of the federal joint taxes, which are divided among the federal, provincial and municipal authorities according to a certain allocation formula, divided by the population of the municipality" [9]. This definition shows that the exclusively municipal levies and the revenue shares from fiscal equalization are of particular importance for the available financial volume of the municipalities. The Fiscal equalization system essentially regulates the distribution of all taxes collected among the federal government, the provinces and the municipalities. First, a distinction must be made between own taxes (which remain with the collecting authority) and joint federal and state taxes, which are divided among the federal government, the states and the communities according to a key and are returned to the Austrian municipalities in the form of the so-called revenue shares from fiscal equalization as an extremely important source of revenue (Fig. 1).

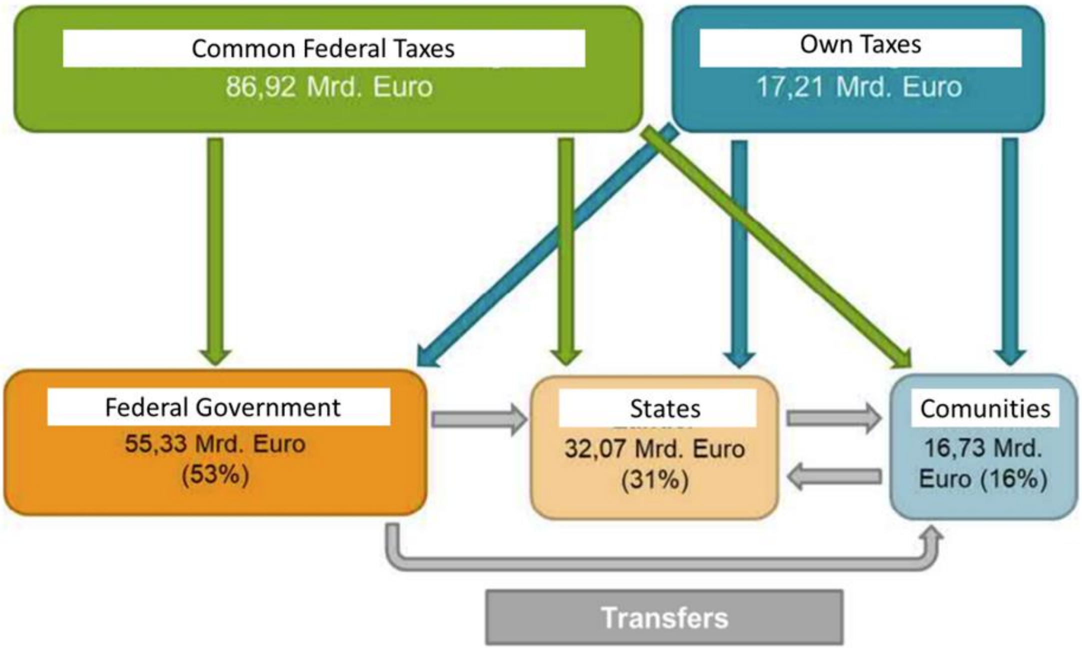

Figure 1. Cash flows under the fiscal equalization scheme for Austria 2018 [10].

In principle, the allocation of funds is based on a key that is renegotiated approximately every 6 years between representatives of the federal government, the states and the municipalities and thus adjusted to developments. From 2011 to 2014, the distribution of levies between the three regional authorities looked as follows: 67.417% was received by the federal government, 20.7% went to the states, and the municipalities received 11.883% [11]. As can be seen from Figure 1, these shares changed in 2018 to 53% (federal government), 31% (states) and 16% at the same time, which equals a significant shift towards states and municipalities. The number of inhabitants of the respective territorial units is considered to be a key control parameter for determining the key; in addition, of course, the amount of tax revenue generated by the territorial unit also influences the amount of revenue shares and thus also the returns (i.e. tax power or - in relation to the number of inhabitants - per capita tax power). It can be seen that a high number of high-quality (and thus "more tax-active") jobs in the production, service and tourism sectors also shifts the level of STKKQ upward. In very simplified terms, it can be said that municipalities with very low populations and a strong agricultural orientation are conspicuous for their particularly low STKKQ.
Concerning Styria as the spatial framework of the study, special attention must be paid to the chronology of the STKKQ coverage in two respects: First, it should be pointed out

that the population figures of the observation year are not used for the calculation, but the adjusted population figures of the respective previous year (i.e., for the STKKQ 2018, the population figures on October 31, 2016 are used; the publication takes place at the end of 2017). On the other hand, although the STKKQ has been calculated since 1957, it does not make much sense to consider the development over this period, especially since the structure of the Styrian municipalities was seriously reshaped, for example, by the structural reform of the municipalities that took effect in 2015. As a result of mergers or regroupings, the original 542 municipalities became 288 (currently 286) units, with only 157 municipalities remaining unchanged. Relevant for the present study is the increase in the average number of inhabitants of Styrian municipalities from 1747 to 3293; at the same time, the share of Styria in the number of Austrian municipalities with less than 1000 inhabitants decreased from 32% to 3.6% (with a simultaneous increase in large municipalities with more than 10000 inhabitants from 5 to 15).

COVID-19 and its possible effects

Longer-term observation - despite all the associated problems - clearly shows how much continent-wide or global events affect the development of STKKQ; for example, the economic and financial crisis of 2008/2009 was partly responsible for a marked slump in STKKQ that was not overcome until 2011. For this reason, a noticeable decline in development could also be expected with some probability for the period of the Corona pandemic, since the study area, together with the rest of Austria, was on its way into lockdown from mid-March 2020, which - apart from summer interruptions and temporary relaxations - severely restricted social and also economic life until mid-March 2021. Attempts were made to react to the effects of the pandemic (supply bottlenecks in production, absence of guests in tourism, etc.) with short-time work, compulsory leave, layoffs ,and company shutdowns, with a decline in tax revenue becoming apparent.

General methodological remarks

The research questions formulated at the outset of this study have resulted in the methodological instruments used in the investigation. Naturally, the statistical evaluation of the available data material is in the foreground, whereby particular importance was attached to the spatial frame of reference. Fortunately, the freely available software package GeoDa (version 1.20) of the development team around Luc Anselin (Center of Spatial Data Science, University of Chicago) is an analysis tool that provides both the appropriate tools for dealing with spatial statistical issues (spatial characteristics, autocorrelation, regression, clustering) and those for analyzing the spatio-temporal dimension of the problem [12]. In addition to the material provided by Statistics Austria [13], the extensive data pool and the (digital) publications of the Styrian Provincial Statistics [14] could be used as a data basis for the analyses. The results presented in this paper are based exclusively on data from the last-mentioned source.

METHODS, RESULTS AND DISCUSSION

For a superficial assessment of the temporal development of the STKKQ with respect to the central tendency and the dispersion of the distributions, a series of box-whisker plots was first created, whereby three times the interquartile range was chosen as the limit value to the extreme outliers [15]. This widening of the range between the limits of the plots allowed on the one hand an assessment of the general development trend, but at the same time should emphasize the extreme values, so that striking outliers could be identified more easily (Fig.2).

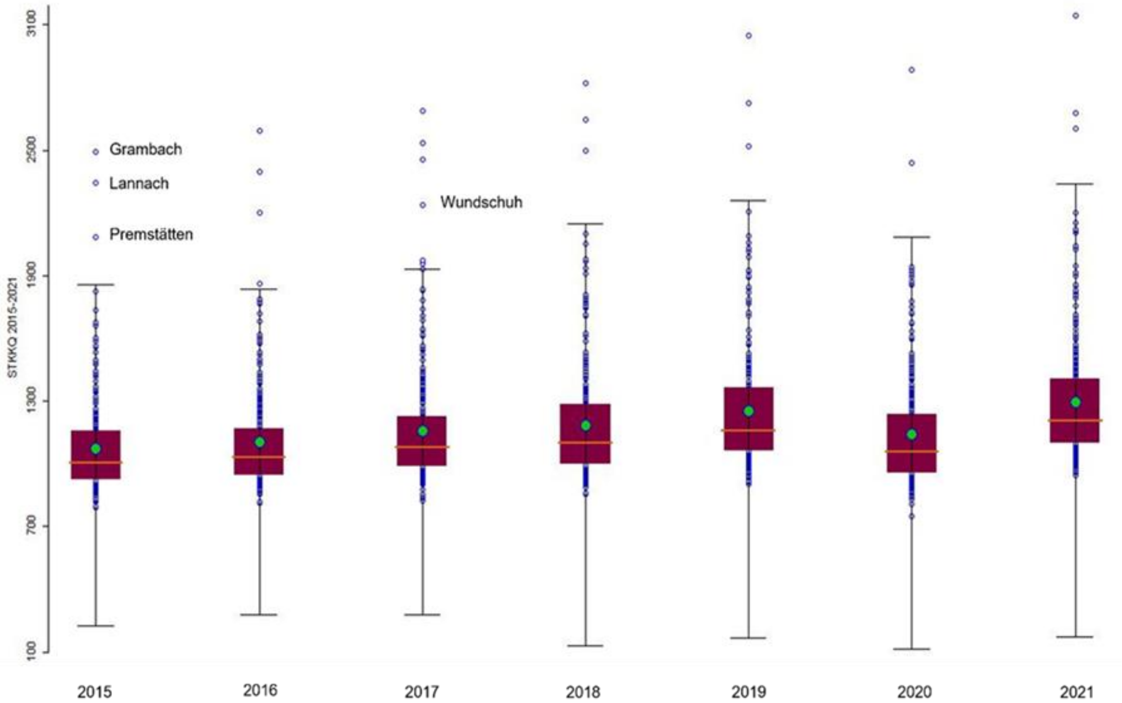

Figure 2. Development of the distribution of STKKQ over time 2015 – 2021

demonstrated. For example, both the median of the distributions and their arithmetic mean showed a slight upward trend (mean 2015: 1073 € to 2021: 1293 €) which, as expected, only experienced a dip due to the pandemic year 2020 (mean 2019: 1250 € and 2020: 1141 €, respectively). Regarding the dispersion behavior of the distributions, the interquartile range (i.e., the "middle" 50% of the values) showed an inconspicuous behavior over the entire period, but it also became clear that the higher values of the STKKQ dispersed much more than the "lower" quarter of the distribution; in other words, the group of municipalities with lower STKKQ is much more compact than those with higher STKKQ. The extremes are particularly noteworthy. During the entire observation period, the same three municipalities are at the top of the ranking: Raaba-Grambach and Premstätten in the immediate vicinity and thus under the influence of the provincial capital Graz, and finally Lannach, a municipality in the catchment area of Graz, which obviously benefits from its status as a highway or railroad junction and the associated locational advantages for industrial and commercial enterprises. Wundschuh is an exception: This municipality, which is located on the supra-regional traffic axis Graz-Maribor, recorded a one-time peak for 2017, which, however, soon leveled off again to the long-term level in the following years.
A different impression of the same facts is provided by the presentation of the numerical material by means of a parallel coordinate plot (PCP), which in principle also describes the time series, but in addition allows a detailed assessment of the chronological development of individual spatial units. The simultaneous standardization of the data material also makes the individual time periods more comparable with each other in a certain sense. Therefore, the representation in Fig. 3 shows the already known development, but in addition, it also enables the isolated consideration of individual municipalities [16].

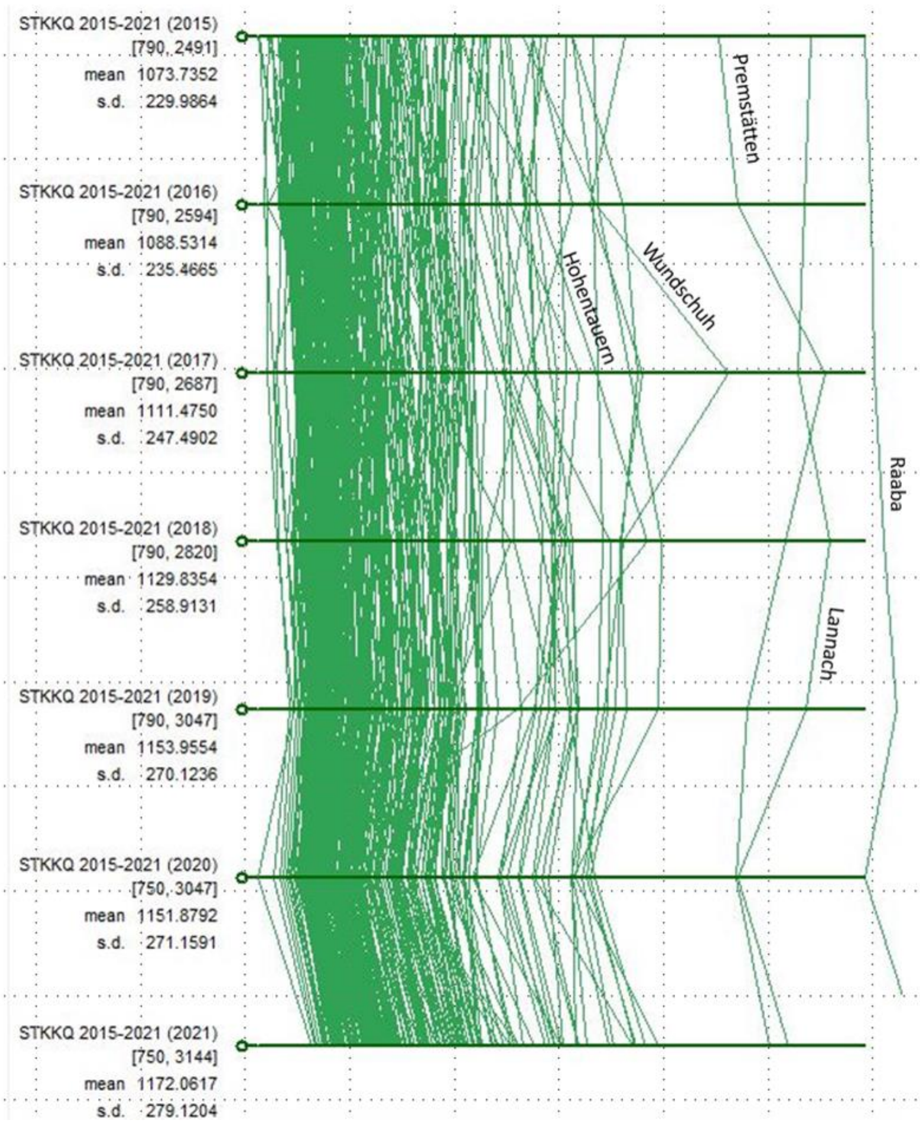

Figure 3. Development over time of STKKQ 2015 - 2021 by municipality

This is of particular interest when these communities cannot be identified in Box-Whisker Plot because this information is overlaid by the prevailing trend. For example, in the present case, in addition to the development of Wundschuh, the situation of Hohentauern, a predominantly winter tourism-oriented Upper Styrian community, during the pandemic becomes apparent.

In addition to the temporal development of the STKKQ, the current situation of the parameter in the first year after the removal of the restrictions is of particular interest, whereby a visualization using the natural breaks concept [17] would be obvious. However, this approach has a disadvantageous effect in that - although describing the actual distribution of the values quite correctly in terms of classification - it merely documents the lack of symmetry of the data set: Using 5 (unequally wide) classes, the lowest class (< 1209 €] is occupied by 146 units (which corresponds to more than half)! In addition, the arithmetic mean would be found in the next higher class, making a mean-based classification into above/below average impossible; the addition of the next higher class (1209 € - 1402 €) with 65 elements would shift this relationship even further and, moreover, mean that all "below average" elements would be considered but only a fraction of the "above average" communities. Alternatively, quantile- or percentile-based classification methods could be used, which describe the distribution of a value series around a mean value. However, it must be kept in mind that this study is less concerned with the question of frequencies of occurrence, but primarily with the extremes and their location in space. For this reason, a symmetrical classification scheme with intervals based on the standard deviation was used to describe the STKKQ. The two middle classes mark the less prominent municipalities with STKKQ around the national mean (70 above, 177 below); the subsequent classes define municipalities with STKKQ significantly (up to two standard deviations) above (19) or below (7) the mean. The marginal classes carry - in relation to the arithmetic mean - the outliers. As far as the spatiotemporal development of the municipalities examined on this basis is concerned, only moderate dynamics can be detected, and the municipalities seem to react relatively sluggishly to quite remarkable external influences (Fig. 4).

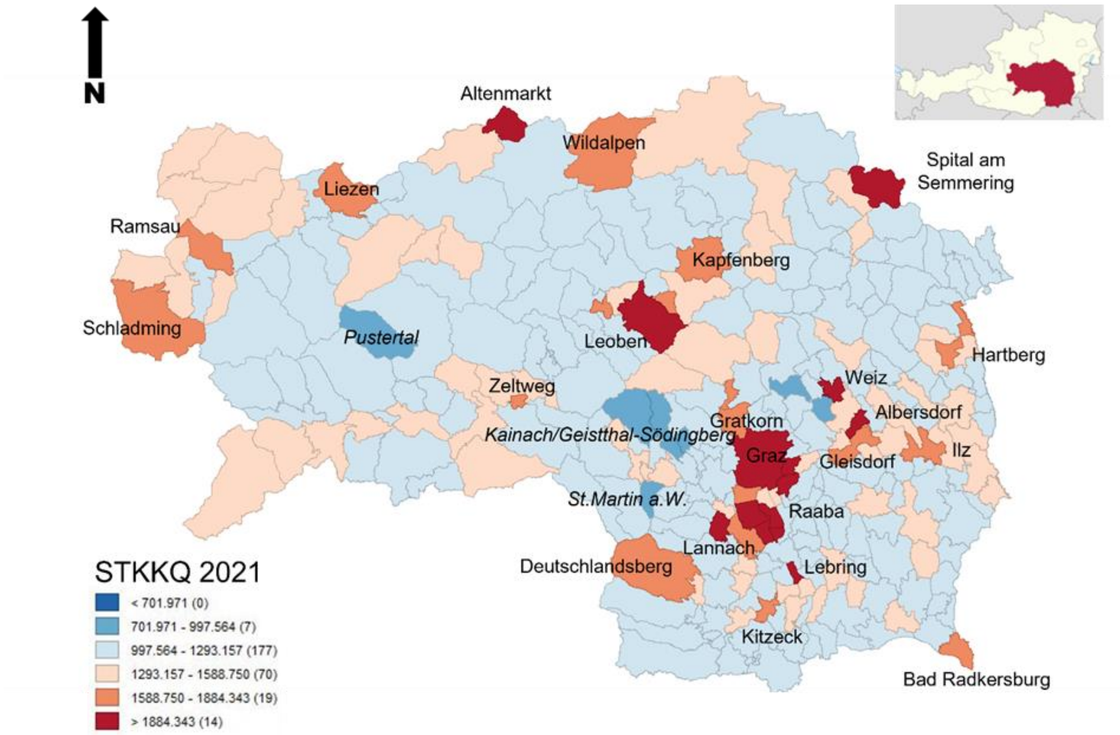

Figure 4. Maxima and Minima of the STKKQ 2021 of the Styrian Municipalities

Apart from revaluations as a result of short-term/one-time events, it was almost exclusively tourism communities that experienced a slump in STKKQ that could be paralleled with COVID-19. In most cases, this was a slip into the next lower class, a process that was already reversed in the following year (exception: the already mentioned Hohentauern, which as a positive outlier of 2017 slipped into the penultimate class and has since then only recovered very slowly. Apart from that, it can be summarized that urban centers with a pronounced share of services (Graz and its southern and eastern neighboring municipalities, Leoben and Kapfenberg as well as cities with higher centrality such as Weiz, Gleisdorf or Liezen) or tourist communities (Schladming, Altenmarkt, Spital am Semmering, Wildalpen or Bad Radkersburg) consistently occupy the top positions. A similar situation, but in the opposite sense, applies to municipalities that are mostly located in the periphery, are predominantly agricultural and structurally weak; Kainach, Geistthal-Södingberg, Stiwoll, St. Martin am Wöllmißberg and others have been in the last class unchanged for years.

In addition to the descriptive-statistical characteristics of the study area, phenomena such as spatial autocorrelation, the tendency to clustering or the interaction of several factors in the shaping of the STKKQ are subsequently analyzed with the help of the methods of explorative analysis of spatial data (ESDA). Because in this study scenario the possible existence of an interaction between the characteristic expressions of two (indirectly or directly) neighboring spatial units is assumed, the consideration of the distance between them or the range of the interaction is of particular importance. The implementation of this parameter into the model is usually done by defining weights; this can be done in two ways - contiguity-based or distance-based. The contiguity of areas describes the extent of their connection and distinguishes between "adjacent in points" (bishop's or queen's case), "adjacent to edges" (rook's case) or "not adjacent" or the order of contiguity (directly or indirectly via 1, 2, 3, ..., n areas). From what has been said, it can be deduced that in the presence of irregularly shaped (administrative) spatial units, queen's contiguity produces a more realistic representation of reality [18]. Additionally, it has to be taken into account that the data-technically necessary limitation of the analysis to the province of Styria is associated with a reduction of potential neighbors at the state borders (edge effect; [19], which can only be counteracted by the use of higher order contiguities. Alternatively, the use of the distance-based approach which takes into account the real distances between the location points representing the areas (usually the centroids) for the calculation of the weighting factor. The distance in this process serves either as a range limit (distance band method) or as a limit on the number of centroids considered (k-nearest neighbor method). In the former case there is no possibility to control how many neighbors are considered for each centroid, in the latter case there is no possibility to influence the actual distances considered. Because of these considerations, both the queen's case (with 1st, 2nd and 3rd order neighbors) and the distance-based model (distance band with 15 km, 20 km and 25 km) or the k-nearest neighbor model with 4, 5 and 6 neighbors were tested for their suitability in the present study. Finally, the decision was made in favor of the distance-based approach with a bandwidth of 15 km, since it corresponded best to the real conditions; moreover, with a non-zero percentage of about 6 %, each study unit could be assigned an average of 16 neighbors.

On this basis, the global Moran's I was determined for the investigation of the spatial autocorrelation of the STKKQ, whose graphical representation allows basal statements about the configuration of the characteristic values in the defined neighborhood of a spatial unit. This calculation results in a value of 0.044 for Moran's I, which at first rather indicates a random distribution, whereas the significance test for I (with 999 permutations) on a probability level of 95 % suggests a weakly pronounced clustering. Nevertheless, the graphical representation of Moran's I is telling in that it allows for a basic identification of HIHI or LOLO communities. The first group includes those areas of the study area where communities with high STKKQ occur in close proximity, while in the LOLO area areas with low STKKQ are surrounded by the same. The enclosed overview maps support the assumption made at the beginning: tourist areas and economically strong municipalities (HIHI) are juxtaposed with agrarian and economically weak areas (LOLO) (Fig. 5).

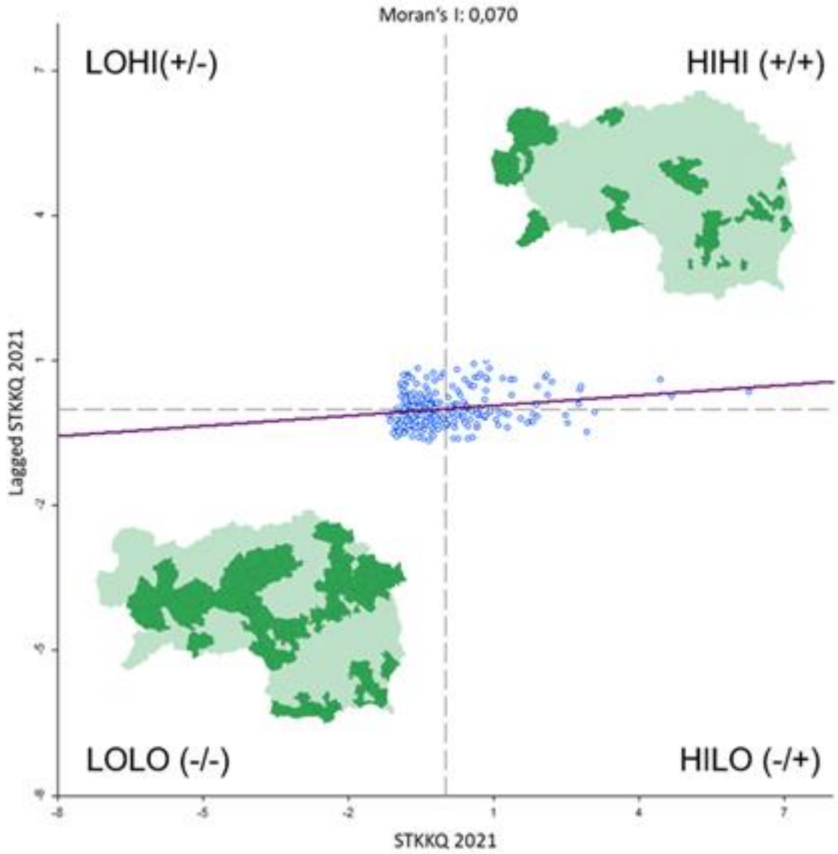

Figure.5. Global Moran‘s I of STKKQ (scatterplot and spatial distribution).

Beyond this statement, however, the global variant of Moran's I is not able to provide information on the more precise spatial distribution of the individual clusters and the associated significance level, so that "localized" I had to be determined additionally. The resulting results confirm in principle the findings derived from Moran's I. Significant results (p = 0.05 or smaller) can only be found for 53 of the 287 Styrian municipalities, whereby previous assumptions had to be corrected in part. Thus, only Graz with its eastern and southern neighbors (14 municipalities) as well as Niklasdorf in Murtal and Bad Aussee, respectively, are found in the significant HIHI range. Also, in the LOLO area the results differ from the "global" view. While the results for the western Styrian municipalities of Maria Lankowitz, Bärnbach and St. Martin am Wöllmißberg could have been expected, a cluster of 10 municipalities in northern eastern Styria and the hitherto inconspicuous municipality of Schöder, for example, are surprising. For a better understanding, however, it should be mentioned that in the described facts only the core areas were identified, that means that it can be assumed that the area characterized in this way also includes the respective neighboring municipalities, so that altogether much larger homogeneous areas are created (Fig.6).

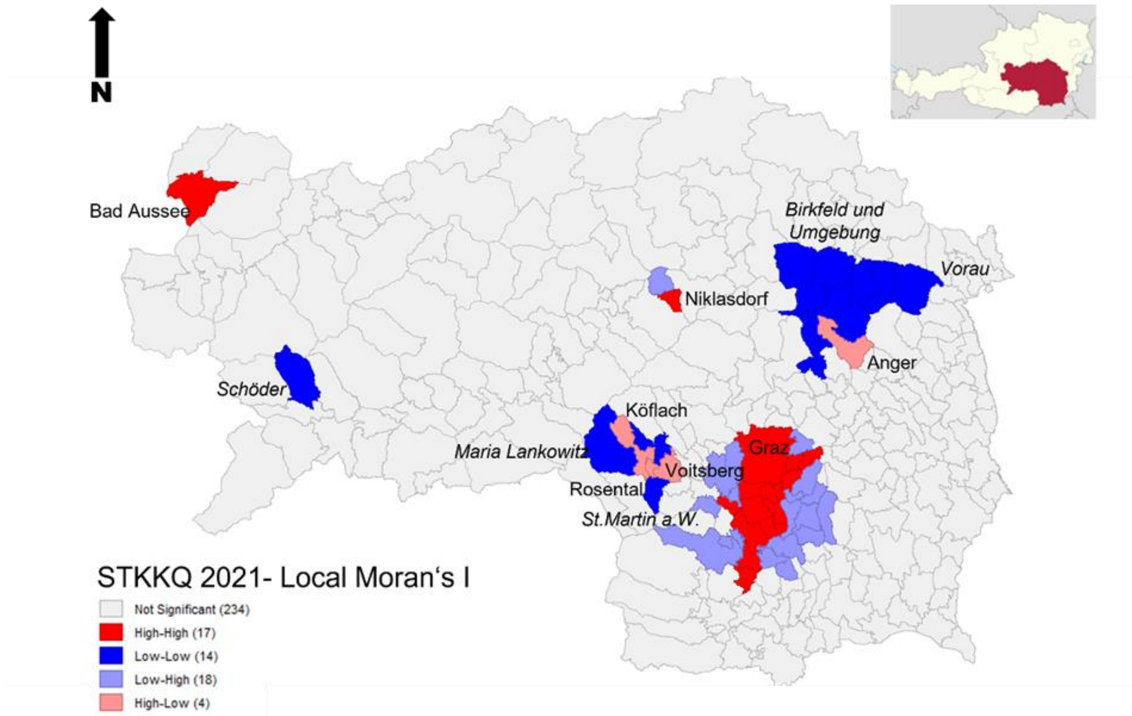

Figure 6. Spatial distribution of significant Local Moran's I (p less than or equal to 0.5).

Extending this approach to delineate STKKQ clusters, an attempt was also made to use cluster analytic methods to structure the entire study area into clusters of municipalities with approximately equal economic power. From the large number of clustering methods, hierarchical clustering was selected as the most suitable method because in this method the number of clusters does not have to be determined a priori, but the clusters can be built up step by step [20]. The size of the cluster is determined from the results of each step, a process that can be easily understood using a dendrogram. In this agglomerative process, the successive steps are performed bottom up and can be interrupted at any point in the process. For the present study, the complete linkage option was used because, unlike single linkage, this method tends to lead to the formation of a larger number of balanced, compact clusters and thus is more likely to satisfy the task as a tool for regionalization [21].

look at the results shows that the described procedure - using automatic weighting based on Euclidean distance - allows the formation of 13 clusters, which not only make sense in the given context (economic/demographic/transportation), but also roughly reflect the current administrative structure of Styria. However, the value for the within-cluster sum of squares (measure for the homogeneity of the cluster) is significantly higher in 2 clusters than in the rest of the study area, while 3 municipalities (Raaba, Premstätten and Lannach form a separate, non-contiguous cluster (Fig.7). Also noteworthy is the fact that the provincial capital Graz is assigned to a cluster in central eastern Styria, thus contributing - albeit indirectly - to the increase in variance within the cluster. Alternatively, the clustering was performed using Ward's variance-minimizing linkage method [22], which slightly decreases the between-cluster sum of squares; nevertheless, there are also massively increased similiarities in two clusters; on the one hand caused by the assignment of Graz and on the other hand by the municipality Lebring, which was assigned as exclave to a cluster south of Graz.

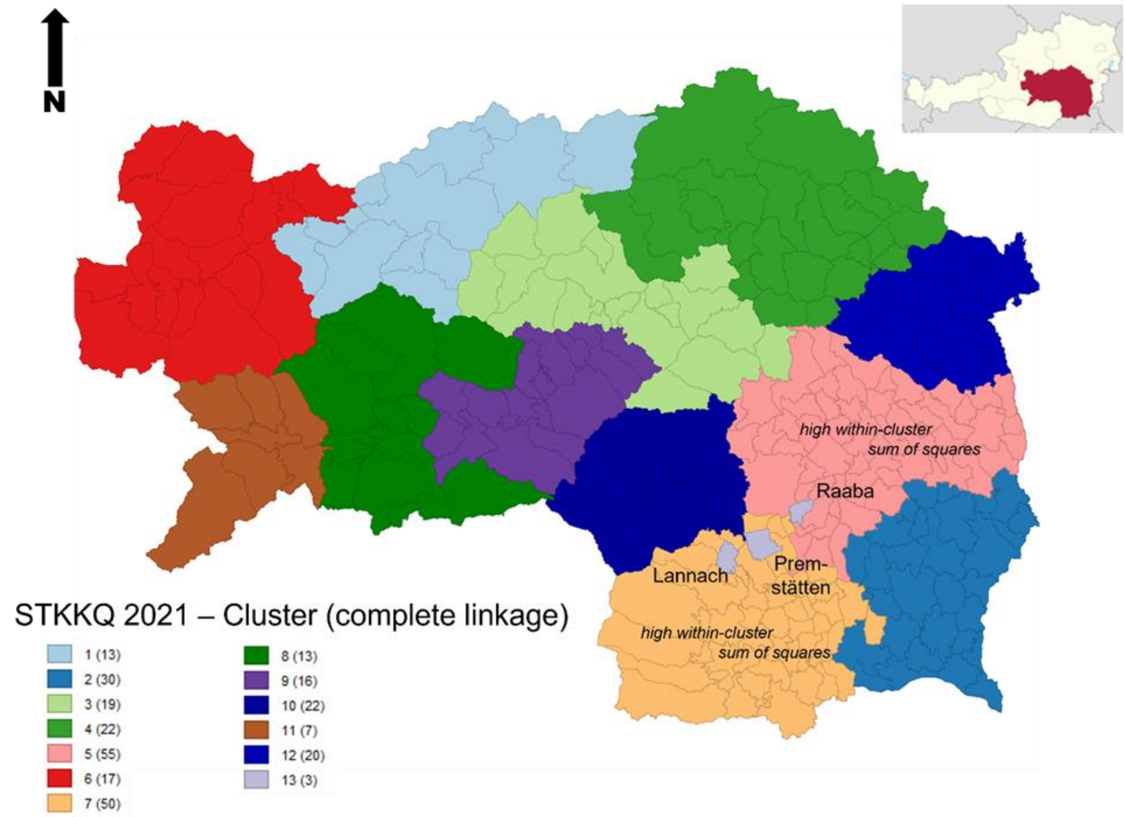

Figure 7. 13 STKKQ – Clusters of Styria (based on centroids and automatic weighting)

Finally, this paper will examine the question of possible statistical correlations between the STKKQ and the control variables of population, number of workers and overnight stays in the calendar year, which may be partly responsible for its level. Unfortunately, it was not possible to include the latter parameter because it turned out in the course of the study that the required data for all observed municipalities could not be obtained in the necessary scope or form. Instead, the factors "tax performance" (sum of all taxes and duties of a municipality, STUA) or "employed in the agricultural sector" (I) or "employed in the tertiary sector" (III) were included in the calculations. The multiple OLS regression model (OLS = Ordinary Least Square) created on this basis yielded an R^2 of 0.30 for the dependent variable STKKQ, which seems surprisingly low in view of the predictors STUA, III, inhabitants (EW) and employees (ACT) used, with only the contributions of I and III to the model being relatively high (coefficients: -24.07 and 3.48, respectively). However, the extremely high value for multicollinearity (Mulitcollinearity Condition Number: 143.06) has a far more severe effect, rendering the model unusable in this form [23]. For this reason, the variables were subsequently examined individually, showing that the variables ACT (R^2: 0.048), EW (R^2: 0.049), and STUA (R^2: 0.054) hardly contribute to the expression of the target variables. In comparison, the dependence of STKKQ on the variables III (R^2: 0.122) and I (R^2: 0.154) is somewhat stronger; in contrast to the former, however, the relationship for the latter is, as expected, in the opposite direction.

SUMMARY

Regarding to the questions formulated above, it can be summarized first of all that the parameter STKKQ has recorded a permanent increase since the municipal structural reform in 2015, which shows a significant drop in parallel to the COVID 19 pandemic. Apart from some local outliers, the development is uniform, so that hardly any significant changes in the ranking occur. A classification based on arithmetic mean or standard deviation yielded for the year 2021 supports this thesis. The results for Moran'I (global) indicate a very weak autocorrelation, which means that there are hardly any dependencies between the municipalities regarding the expression of the STKKQ. This finding is also consistent with the results for I at the local level, which show that HIHI or LOLO are also significant in only a few cases (31 out of 287). The attempt to group communities of similar STKKQ using hierarchical clustering suggested the formation of 13 clusters, although it must be emphasized that this result represents an administratively justified compromise between spatial compactness and the similarity of the communities within the clusters. An examination of the dependence of the STKKQ on certain socioeconomic variables showed only an unexpectedly weak dependence on the factors "employed in the primary sector" (negative) and in the "tertiary sector" (positive). A significant influence of the other variables could not be detected.

Acknowledgments
The research work described in this paper was greatly facilitated by the unbureaucratic provision of basic digital data by Hofrat Dipl.-Ing. Martin Mayer, Head of the Department for Statistics and Geoinformation (A17, Landes- und Regionalentwicklung der Steiermärkischen Landesregierung). The author is therefore greatly indebted to him.

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GIS BASED WATER QUALITY ASSESSMENT OF ANADERE STREAM BASIN A SIGNIFICANT SUB-BASIN OF ERGENE RIVER IN THRACE REGION (TÜRKIYE)

DOI: https://doi.org/10.18509/GBP23217t
UDC: 528.8:004.6/.7]:556.51.04(282.247.1:560)

Cem Tokatli
Trakya University, Evrenos Gazi Campus, Edirne, **Türkiye**

ABSTRACT

Water pollution has become a global concern in especially recent years and contamination of freshwater habitats is top of attention for all over the world. Anadere Stream Basin, which is known as being adversely affected from agricultural and domestic discharges, is one of the most significant sub – basin of Ergene River that is the most significant watershed in Thrace Region of Türkiye. The aim of this research was to investigate the water quality of Anadere Stream Basin by measuring a total of 10 significant water quality assessment parameters including dissolved oxygen (DO), oxygen saturation (%O2), pH, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, nitrate (NO3), nitrite (NO2) and phosphate (PO4) and to assess the water quality by using Geographic Information System (GIS). For this purpose, surface water samples were collected from 12 selected stations (from upstream to downstream; A1 – A12) located on the Anadere Stream Basin in winter season (December) of 2019. As a result of this study, the mean recorded values of investigated water quality parameters in Anadere Stream Basin were found as: 11.37 mg/L for DO, 107.83% for %O2, 8.48 for pH, 729.15 µS/cm for EC, 447.50 mg/L for TDS, 0.45 ‰ for salinity, 27.30 NTU for turbidity, 1.81 mg/L for NO3, 0.03 mg/L for NO2 and 0.30 mg/L PO4.

Keywords: Anadere Stream Basin, Water quality, Geographic Information System

INTRODUCTION

Especially due to the increasing population, unconscious consumption of natural resources and insufficient environmental awareness in humans, environmental pollution has become one of the most important problems in the world in recent years [1 – 3]. Freshwater pollution by especially organic pollutants because of agricultural and domestic discharges are among the most important environmental issues all around the world [4 – 7].

Thrace Region is located on the northwest part of Türkiye. Although the region covers about 3% part of country, approximately 15% of the total population lives in this region [8 – 10]. Ergene River Basin, which is one of the main parts of the Meriç River Basin, is one of the most important watersheds located in the Thrace Region of Türkiye. Anadere Stream Basin, which is located in the north-west part of Türkiye, is one of the most important sub–basin of Ergene River and it is being adversely affected by agricultural and domestic wastewater discharges [11 – 13].

The main objectives of this investigation were (1) to assess the water quality of Anadere Stream Basin by determining a total of 10 important limnological parameters (dissolved oxygen, oxygen saturation, pH, electrical conductivity, total dissolved solids, salinity, turbidity, nitrate, nitrite and phosphate) and (2) to evaluate the water quality by using Geographic Information System (GIS).

MATERIALS AND METHODS

Sample collection

In the present research, freshwater samples were collected from 12 locations selected on the Anadere Stream Basin in rainy (winter) season of 2019. The coordinate information of the selected stations is given in Table 1 and the topographic map of study area with the selected sampling points are given in Figure 1.

Psychochemical Analysis

Dissolved oxygen (DO), oxygen saturation (%O2), pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity variables were determined by using a multi – parameter device (Hach Lange – HQ40D) in the field studies; turbidity variable was determined by using a portable turbidimeter device (Hach Lange – 2100Q) in the field studies; nitrate (NO3), nitrite (NO2) and phosphate (PO4) variables were determined by using a colorimeter device (Hach Lange – DR890) in the laboratory studies.

Table 1. Coordinate information of the sampling points

Station Code	Name of Habitat	GPS – North	GPS – East	Station Code	Name of Habitat	GPS – North	GPS – East
A1	Bağlar Stream	41.814	26.845	**A7**	Söğütlü Stream	41.639	26.802
A2	Keldere Stream	41.802	26.877	**A8**	Büyükçobanlı Stream	41.641	26.825
A3	Reselli Stream	41.730	26.846	**A9**	Köydere Stream	41.572	26.747
A4	Toy Stream	41.725	26.819	**A10**	Olukbaşı Stream	41.559	26.782
A5	Somurcalı Stream	41.721	26.796	**A11**	Anadere Stream	41.421	26.821
A6	Akardere Stream	41.636	26.755	**A12**	Anadere Stream	41.347	26.885

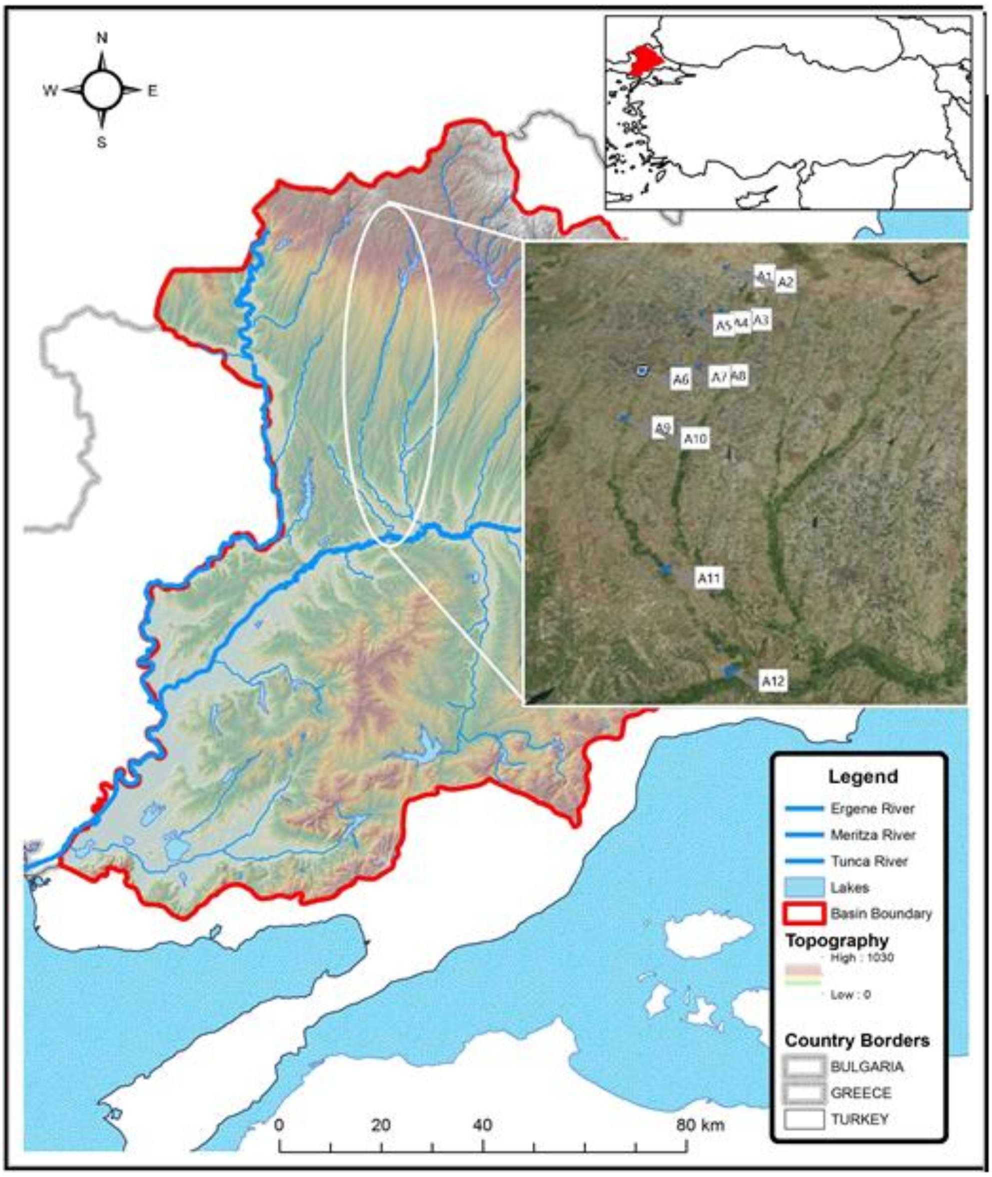

Figure 1. Ergene River Basin and selected stations on the Anadere Stream Basin

RESULTS AND DISCUSSION

The results of measuring 10 water quality parameters in Bağlar, Keldere, Reselli, Toy, Somurcalı, Akardere, Söğütlü, Büyükçobanlı, Köydere, Olukbaşı, Anadere Streams are given in Figure 2 and the GIS based distribution maps of selected 6 significant water quality parameters in the basin are given in Figure 3.

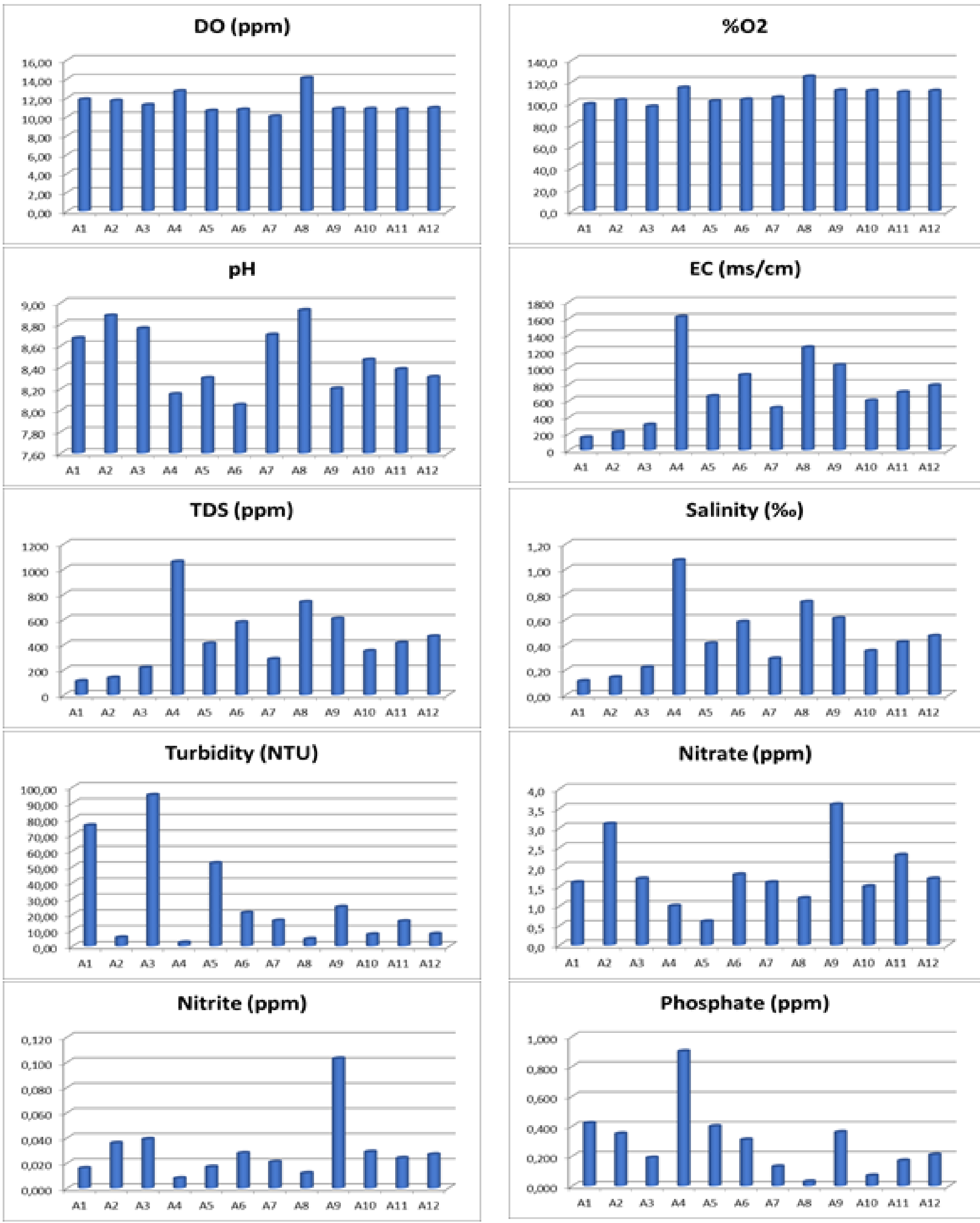

Figure 2. Results of investigated parameters

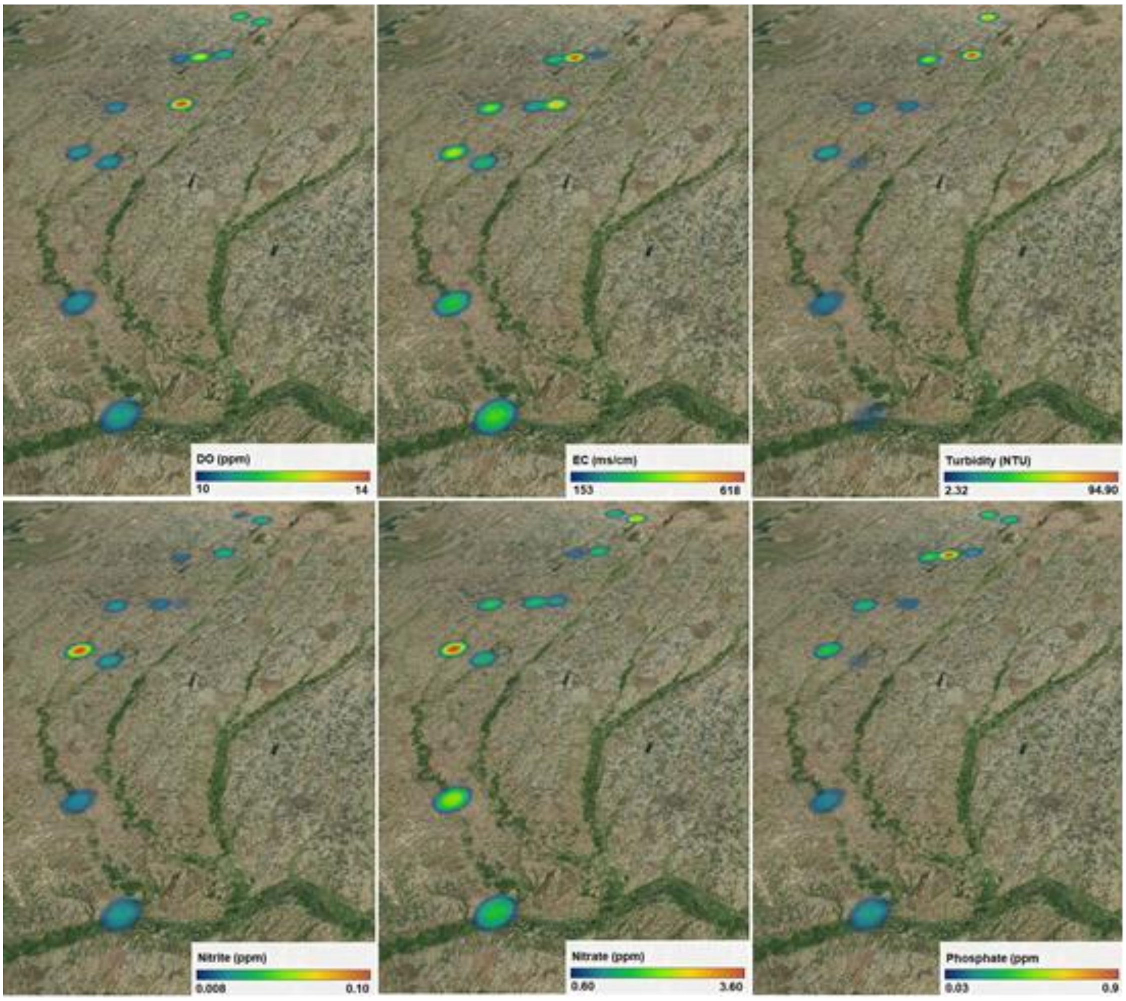

Figure 3. GIS based distribution maps of parameters

Significant spatial differences were not detected in dissolved oxygen, oxygen saturation, pH and nitrate values and the mean values of these parameters in the water of Anadere Stream were 11.37 mg/L, 107.83%, 8.48 and 1.81 mg/L respectively.

Nevertheless, significant spatial differences were detected between EC, TDS, salinity, nitrite and phosphate values. While the highest EC, TDS and salinity values were detected at the A4 (Toydere Stream) station (1618 µS/cm, 1057 mg/L and 1.07 ‰ respectively), the lowest EC, TDS and salinity values were determined at the A1 (Bağlar Stream) station (154 µS/cm, 110 mg/L and 0.11 ‰ respectively). The minimum and maximum levels of nitrite and phosphate parameters in the basin waters were recorded as 0.008 mg/L – 0.103 mg/L for nitrite and 0.030 mg/L – 0.901 mg/L for phosphate.

Anadere Stream Basin has 1st class (> 8 mg/L) water quality in terms of DO parameter; it has 2nd class (400 – 1000 µS/cm) water quality in terms of EC parameter; it has 1st class (< 3 mg/L) water quality in terms of NO3 parameter; and it has 3rd class (> 0.16 mg/L) water quality in terms phosphate parameter [14].

It has been determined that the organic pollutant contents of the Anadere Stream Basin waters, especially the phosphate contents, were recorded as at slightly high levels. Agricultural applications may significantly raise the concentrations of nitrogen and phosphorus compounds in soil and water and it is clearly known that one of the main anthropogenic resources of phosphate is domestic wastewater [15 – 18].

To evaluate the contamination status of the investigated parameters in waters of the Anadere Stream Basin, the levels of water quality parameters obtained from the current research were compared with those reported by previous investigations in Türkiye (Table 2).
The average levels of dissolved oxygen and pH values detected in the waters of Anadere Stream Basin in the current research were higher than detected in Meriç and Ergene Rivers and Emet, Porsuk and Sazlıdere Streams. Nitrite and phosphate values recorded in the current research were found to be lower than the other compared lotic ecosystems except the Meriç River, while the EC and salinity variables were higher than the other compared aquatic habitats except the Ergene River and Sazlıdere Stream [19 – 22].

Table 2. Comparison of parameters in current study with other fluvial habitats

	DO mg/L	**pH**	**EC** µS/cm	**Sal** ‰	**Tur** NTU	**NO_3** mg/L	**NO_2** mg/L	**PO_4** mg/L	**Reference**
Anadere Stream	11.37	8.48	729	0.45	27.30	1.81	0.03	0.30	Current Research
Meriç River	8.67	8.22	327	0.18	6.17	1.90	0.02	0.16	[19]
Ergene River	4.57	7.81	1645	0.93	48.13	0.90	0.11	0.59	[19]
Emet Stream	9.32	7.92	652	0.39	-	1.23	0.03	0.68	[20]
Porsuk Stream	7.71	7.69	618	0.32	-	1.37	0.08	-	[21]
Sazlıdere Stream	9.99	8.34	761	0.49	12.50	2.00	0.04	0.39	[22]

DO: Dissolved oxygen; Sal: Salinity; Tur: Turbidity

CONCLUSIONS

measuring some significant water quality assessment parameters. According to the result of this study, water of Anadere Stream Basin was found as slightly contaminated by organic pollutants. The water of the basin has 1st class water quality in terms of DO and nitrate parameters, while it has 2nd class water quality in terms of EC parameter and has 3rd class water quality in terms phosphate parameter.
In line with the current data, it may be recommended that use of unconscious fertilizers must be avoided in the region and discharges of municipal sewage without any treatment must be prevented in order to improve the quality and provide the sustainability of aquatic life in the Anadere Stream Basin.

Acknowledgements
The present study was funded by the Trakya University, Commission of Scientific Research Projects (Project No. 2018/154).

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LONG-TERM (2012-2022) SPATIOTEMPORAL MODIS-DERIVED AEROSOL OPTICAL DEPTH ANALYSIS OF IĞDIR CITY, TÜRKİYE

DOI: https://doi.org/10.18509/GBP23225s
UDC: 528.88.06:[502.3:504.5"2012/22"(560)

Aliihsan Sekertekin[1]
Fatemeh Ghasempour[2]
Senol Hakan Kutoglu[2]
[1]Department of Architecture and Town Planning, Vocational School of Higher Education for Technical Sciences, Igdir University, **Türkiye**
[2]Department of Geomatics Engineering, Zonguldak Bulent Ecevit University, Zonguldak, **Türkiye**

ABSTRACT

Remote sensing (RS) technologies provide valuable information about air quality assessment in various scales and time intervals, which enables understanding the effects and trends of anthropogenic activities. Atmospheric aerosols are generally monitored using satellite-based Aerosol Optical Depth (AOD) data. Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Aqua and Terra satellites is one of the primary sources that makes it possible to obtain daily AOD observations. In this study, we aim to evaluate long-term (2012-2022) spatiotemporal MODIS-derived AOD data over Iğdır Province of Türkiye with wind properties. Concerning air pollution, Iğdır is one of the most polluted cities not only in Türkiye but also in Europe. Thus, continuous and long-term monitoring of air quality in Iğdır city is vital for the environmental sustainability and public health. For spatiotemporal analysis, seasonal AOD images were extracted for each year, from 2012 to 2022, and then mean of them were calculated to obtain long-term mean seasonal AOD images. Overall, the mean seasonal AOD values varied almost between 0 and 0.4. The results showed that in general the northern part of the study area has higher AOD values than the southern part, except for the mean of the spring seasons. On the other hand, the wind pattern, in mean seasonal summer, is almost opposite to the other mean seasonal wind directions. This research presents preliminary results, thus to reveal the main source of the aerosols, extensive multisiciplinary study should be conducted in the study area.

Keywords: Air Quality, Air Pollution, Wind Direction, MODIS AOD, Iğdır, Türkiye

INTRODUCTION

Aerosols are tiny particles, which are suspended in the atmosphere with aerodynamic diameters between 0.001-100 µm, and they play a significant role in human health [1, 2], earth-atmosphere radiation balance [3, 4], aerosol-cloud interaction [5], climate change obtained by diminishing or reinforcing the warming at regional and global scales [6, 7]. In order to monitor Aerosol Optical Depth (AOD), there are two different data sets, including ground-level monitoring/station data and satellite-based observations [8-11]. Compared to the ground-based observations, satellite-derived AOD measurements enable long-term AOD monitoring at a regional or global scale [12]. In particular, the Multi-Angle Implementation of Atmospheric Correction (MAIAC) AOD product extracted from Terra and Aqua satellites at high spatial and temporal resolution (1 km, daily) has provided a distinctive opportunity to investigate the micro-scale AOD changes over time and space [13, 14]. It is worth mentioning that satellite-derived AOD data usually endure missing data due to the bright surfaces or the surfaces covered by cloud/snow [12, 15]. To compensate the missing data gaps in the satellite-derived AOD, various methods have been offered with numerous spatial and temporal coverages [16, 17]. In this study, the missing data issue was not handled since long-term mean images eliminated the cloud problem, except for the winter season. This paper aims to investigate the spatial and temporal analysis of long-term (from 2012 to 2022) MODIS-derived AOD over Iğdır province, Türkiye, with wind direction vectors extracted from monthly aggregated ERA5.

STUDY AREA

Figure 1 illustrates the study area considered in this research. Iğdır province, with 3 districts and 163 villages (http://www.igdir.gov.tr/ilcelerimiz/), is located in the Eastern Anatolia Region of Türkiye and along the borders with the countries of Armenia, Iran, and Azerbaijan. It occupies an area of 3,539.00 km^2 and a total population of 203,594.00. Its average altitude is about 850 m from the mean sea level and there is a continental semi-arid climate with hot-dry summers and cold-snowy winters. It is also one of the driest cities in Türkiye with an average precipitation of about 261 mm per year. Air pollution is intensely experienced in the province because of the geographical location, topographic structure, meteorological conditions, microclimate features and a high level of pollution due to the inversion event.

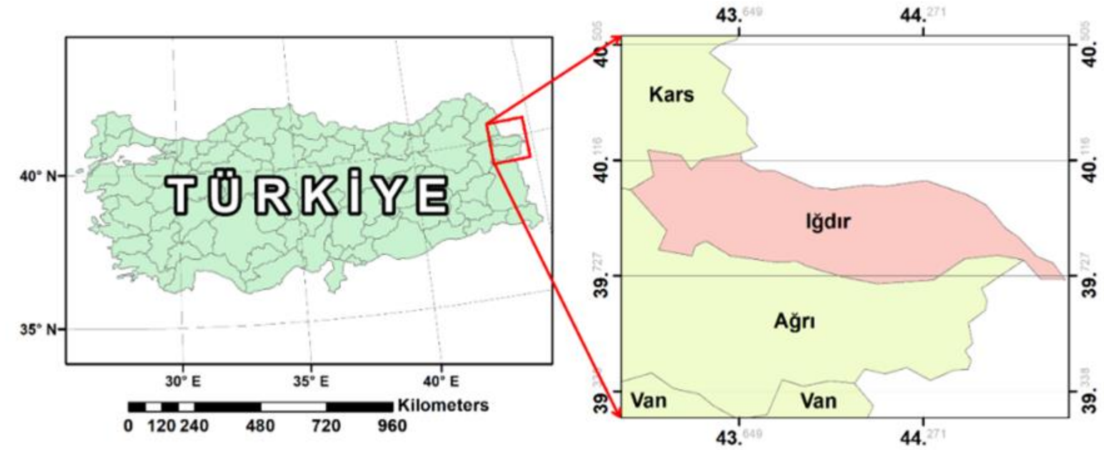

Figure 1. The location map of the study area

RESEARCH DATASET

In this study, we utilized two different sources of the dataset, MODIS-derived AOD dataset at 470nm and ERA5-derived wind components between 2012 and 2022. To trace atmospheric aerosols, we collected the daily AOD images of MODIS (MODIS/006/MCD19A2_GRANULES), which are freely accessible in the Google Earth Engine (GEE) data catalog. This product is provided by the Land Processes Distributed Active Archive Center (LP DAAC) within the NASA Earth Observing System Data and Information System (EOSDIS) located at the USGS Earth Resources observation and science (EROS) center [18]. ERA5 is a global climate/weather reanalysis dataset launched by the European Center for Medium-range Weather Forecasts (ECMWF) under the Copernicus Climate Change Service [19]. To prepare a reanalysis dataset, a combination of model data with a wide range of sensor- and ground-based observations, including different meteorological parameters, are utilized based on the laws of physics. We employed the monthly aggregate of ECMWF ERA5 land data (ECMWF/ERA5_LAND/MONTHLY_AGGR) in this study, and we investigated the visualized relationship between satellite-derived AOD and ERA5-based zonal and meridional wind at the spatial resolution of $0.25^{\circ} \times 0.25^{\circ}$.

METHODOLOGY

To investigate the long-term spatiotemporal changes of AOD over Iğdır province, the methodological steps were performed in GEE cloud platform. Figure 2 illustrates the methodology on a work-flow scheme. The main steps in the methodology are divided into three sections, namely, pre-processing, processing, and exports, referring to grey, orange, and green colors, respectively.

The grey-colored pre-processing step contains the following sub-steps:

MODIS-derived AOD

- Filter image collection by date: the prime step is the introducing of the interested period (2012-2022) as an input parameter.
- Select the interested band: AOD data collection is derived from two different wavelengths including blue and green bands. We opted blue band AOD at a wavelength of 470nm.
- Multiply all images to a scale factor: according to the AOD image collection in Earth Engine Data Catalog, it is essential to apply a scale factor value of 0.001 to all images.
- Clip all image collection over the region of interest: to investigate the variations over the study area.

ERA5-derived meteorological parameter

- Filter date on the dataset between 2012 and 2022: this step is applied to collect the data for the corresponding time interval.
- Select interested bands as u- and v- components of wind at the height of 10m from the ground surface: ERA-5 wind data collection are derived into two components as two different direction of Cartesian coordinate system. U-component is in the west-ward direction called zonal component while V-component is in the south-ward direction called meridian component. To calculate the true wind direction and wind speed, we used these components.
- Clip all image collection over Iğdır province.
- Calculate the wind speed values and wind direction vectors based on equations (1) and (2)

$$T = \left(T_u^2 + T_v^2\right)^{0.5} \qquad (1)$$

$$T_\theta = 270^{o} - \arctan\left(T_v / T_u\right) \qquad (2)$$

Where T, T_θ, T_u, and T_v are wind speed value, wind direction, and zonal and meridional components, respectively.

The processing step with orange color includes functions for extracting seasonal average images including the period from 2012 to 2022. Therefore, we extracted the four image sets as the four seasons for each year.

The green-colored results extracted from the processing step demonstrated two different formats including charts and visualized maps. It is worth noting that visualized maps are comprised the 44 seasonal maps and 4 long-term mean seasonal maps.

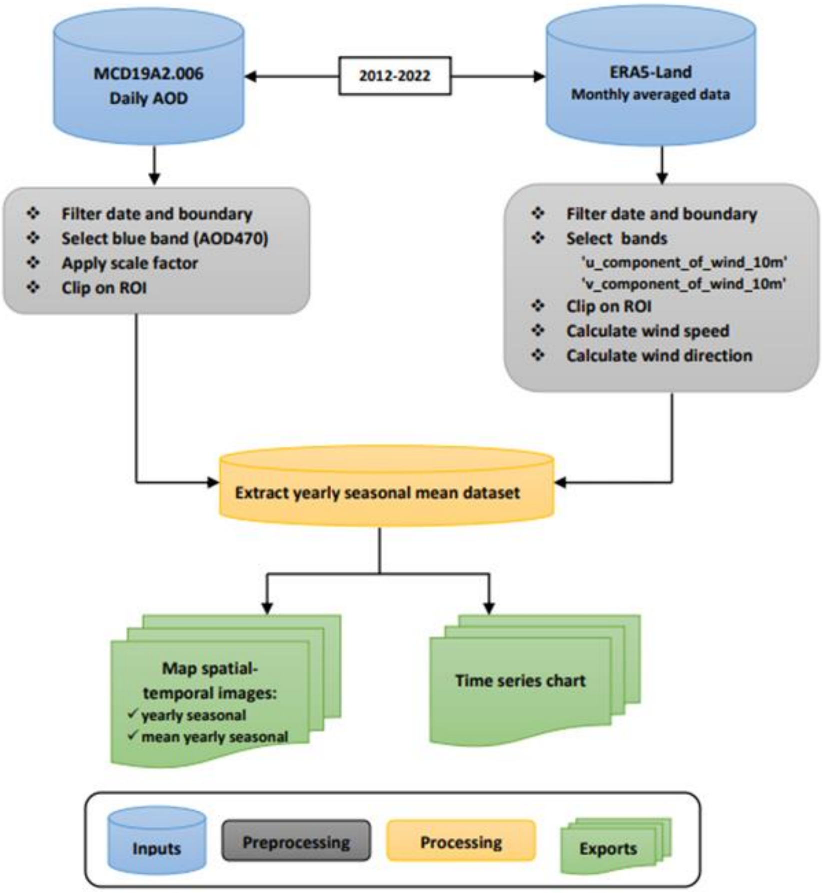

Figure 2. The work-flow scheme used in this study

RESULTS

As stated in the methodology, from 2012 to 2022, seasonal AOD images were extracted for each year. Therefore, we had four AOD images representing spring, summer, fall, and winter for each year. After extracting these seasonal AOD images, mean of them were calculated to obtain long-term mean seasonal AOD images for the study area. Overall, the mean seasonal AOD values varied almost between 0 and 0.4. Figure 3 represents long-term (11-year) mean spring AOD image with seasonal mean wind properties on it. The wind speed is associated with the length of the black bar, and the red circle shows the wind direction. Concerning the long-term mean spring AOD image (Figure 3), it is clear that dense AOD distribution is observed at the Southwest of the study area, and also the Northeast parts have average AOD pattern based on the legend. The wind direction is mainly from south to north and the wind speed is higher at the west side from the middle of the study area. Figure 4 illustrates the long-term (11-year) mean summer AOD image. This mean summer AOD image reveals that most of the study area has high aerosol concentration except for a small area at the southern and western parts of the study area. Considering the wind properties in Figure 4, the wind pattern is almost opposite to the springtime in Figure 3. Figure 5 and Figure 6 show the long-term (11-year) mean fall and winter AOD images, respectively. The wind pattern in these images demonstrates similar trend as in springtime. Additionally, the severity of the wind speed in the long-term mean winter AOD image is the highest among all long-term mean images. In Figure 5, it is clear that the distribution of the aerosol concentration is not very high in long-term mean fall image. On the other hand, in the long-term mean winter image (Figure 6), the AOD values are higher at the Northern part compared to the Southern part. Besides, the missing data are observed at the Southern part of the image in Figure 6 due to long-term seasonal cloud coverage. In general, the primary sources of aerosols are biomass burning smoke and urban/industrial emissions, while the secondary sources are gaseous aerosol precursors, dust and sea salt. In this study, the main source of the aerosol distribution is most probably related to the desertification around the study area. Due to the desertification, particulate matters are transported via the wind. In order to prove the main sources of aerosols in the study area, multidisciplinary and extensive research is required.

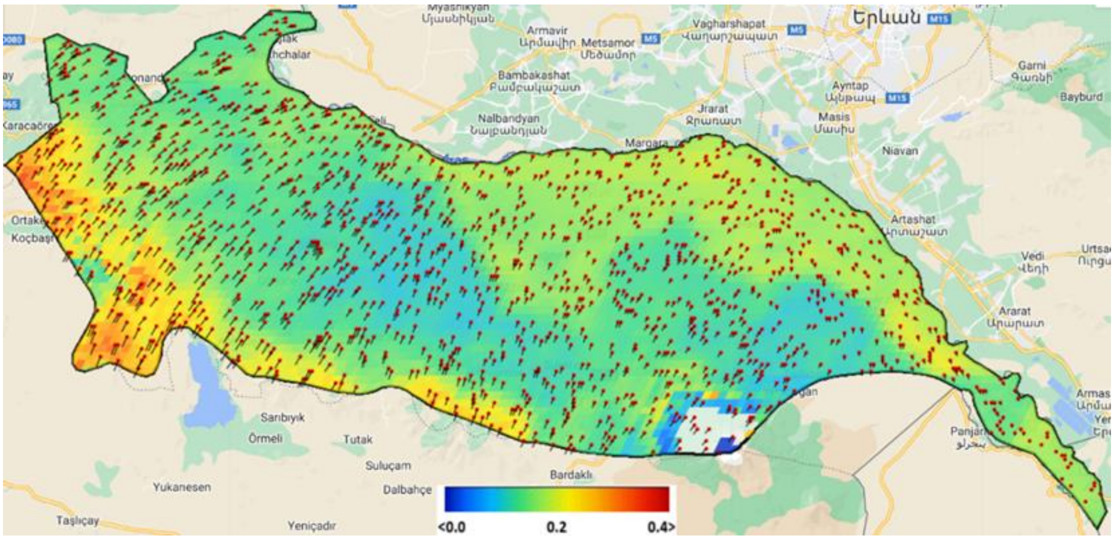

Figure 3. Long-term (11-year) mean spring AOD image with seasonal mean wind properties

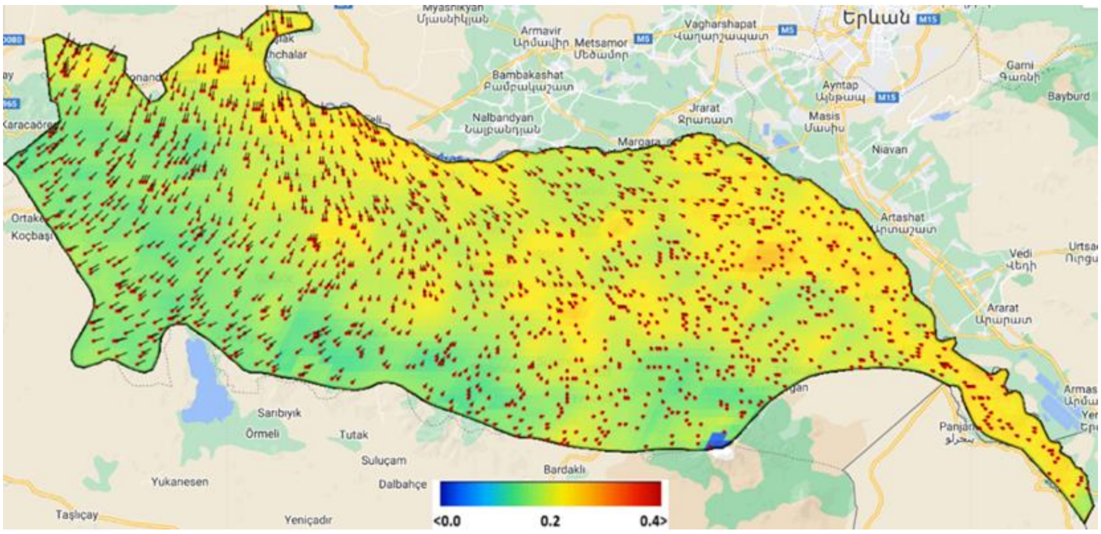

Figure 4. Long-term (11-year) mean summer AOD image with seasonal mean wind properties

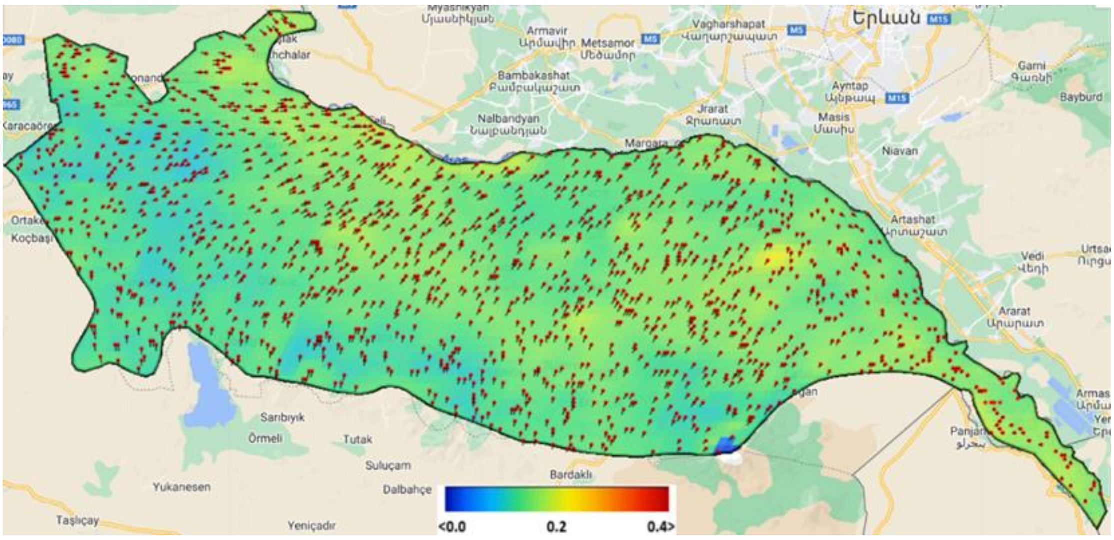

Figure 5. Long-term (11-year) mean fall AOD image with seasonal mean wind properties.

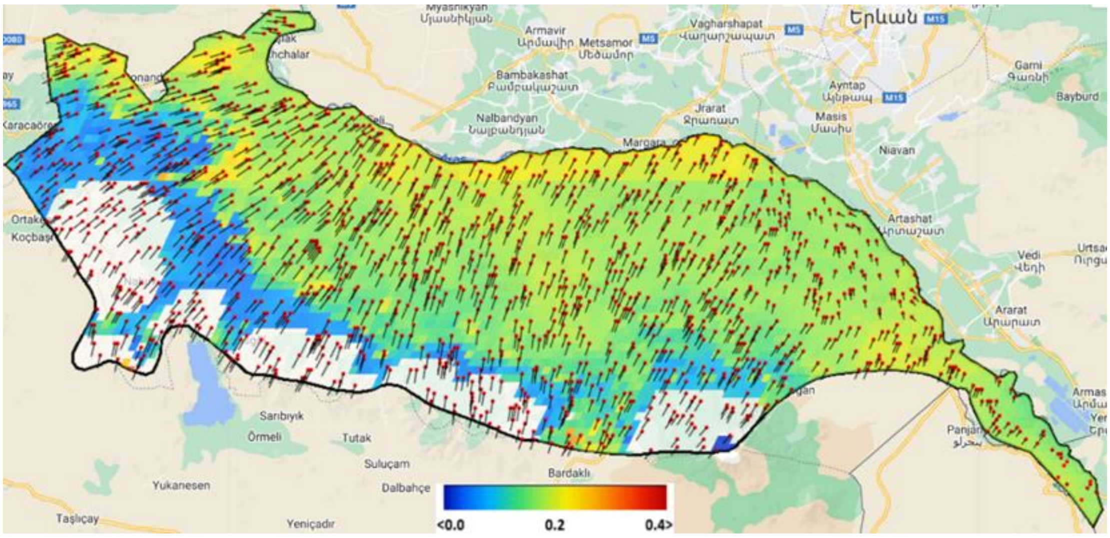

Figure 6. Long-term (11-year) mean winter AOD image with seasonal mean wind properties.

CONCLUSIONS

In this preliminary research, long-term (from 2012 to 2022) seasonal MODIS-derived AOD was investigated over Iğdır province, Türkiye, together with seasonal mean wind properties. The methodological steps were performed in the GEE cloud platform to extract seasonal mean AOD and wind maps. The results showed that in general the northern part of the study area has higher AOD values than the southern part, except for the mean of the spring seasons. On the other hand, the wind pattern, in mean seasonal summer, is almost opposite to the other mean seasonal wind directions. The study area is an important agricultural region; however, desertification issue is observed around its surrounding. Thus, this issue is thought as the main source of the aerosols in this area because of the particulate matters that are transported via the wind. In order to prove this argument, extensive studies should be conducted with other disciplines that will reveal the source of the aerosol in the study area.

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APPLICATION OF GIS FOR AN ECOTOXICOLOGICAL RISK ASSESSMENT OF HEAVY METALS IN WATER OF TWO SIGNIFICANT DAM LAKES LOCATED IN MARMARA REGION, TÜRKIYE

DOI: https://doi.org/10.18509/GBP23233t
UDC: 528.88:004.6/.7]:[627.81:504.5(560)

Cem Tokatli
Trakya University, Evrenos Gazi Campus, Edirne, **Türkiye**

ABSTRACT

Reservoirs, which are mainly being used for irrigation and drinking water supply and flood protection, are among the most significant lacustrine freshwater habitats. However, they are adversely affected by anthropogenic contamination pressure especially in recent years. Atikhisar and Alibey Dam Lakes are two of the most important reservoirs in the Marmara Region. They were built for irrigation and drinking water supply in the Çanakkale and İstanbul Provinces. In this study, surface water samples were collected from the inputs and output regions of Atikhisar and Alibey Dam Lakes (total of 4 locations) in the dry season (end of summer) of 2022. Mercury (Hg), nickel (Ni), selenium (Se), barium (Ba), arsenic (As), cadmium (Cd), strontium (Sb) and boron (B) contents were determined in the collected samples, and the water quality of investigated locations were evaluated by applying some ecotoxicological risk assessment indices including Heavy Metal Pollution Index (HPI) and Heavy Metal Evaluation Index (HEI). Also, Geographic Information System (GIS) was used to provide a visual summary of the applied indices. As a result of the study, the reservoirs found as "Low heavy metal contamination" in terms of applied HPI and "Low contamination" in terms of applied HEI. It was also determined that the heavy metal pollution ranking of the dams in terms of applied indices were as follows: Alibey Dam Lake > Atikhisar Dam Lake.

Keywords: Atikhisar Dam Lake, Alibey Dam Lake, Toxic elements, Ecotoxicological Risk Assessment Indices, Geographic Information System

INTRODUCTION

Heavy metals are hazardous inorganic pollution factors that are toxic even at very low levels. They may enter to the water environment through industrial or domestic wastewater and surface runoff or drainage water from agricultural [1 – 3]. Especially in recent years, heavy metals, which are an important stress factor in aquatic ecosystems, can reach humans through the food chain [3 – 5].

Atikhisar Dam is a dam built between 1971-1975 for irrigation and flood control purposes in Çanakkale, on Sarıçay Stream. The body volume of the dam, which is an earth body fill type, is 1.990.000 m^3, its height from the riverbed is about 43 meters, the lake volume at normal water level is 40 hm^3, and the lake area at normal water level is 3.30 km^2. It provides irrigation service to an area of 5200 hectares [6].

Alibey Dam is a dam built between 1975-1983 on Alibey Stream in Istanbul for the purpose of supplying drinking, utility and industrial water. The body volume of the dam, which is an earth body fill type, is 1.930.000 m^3, its height from the riverbed is about 30 m, the lake volume at normal water level is 66.80 hm^3, and the lake area at normal water level is 4.66 km^2. It provides 39 hm^3 of drinking water per year [7].

Heavy metals such as nickel, arsenic and cadmium can diminish mental and central nervous system function; elicit damage to blood composition as well as the kidneys, lungs, and liver; and reduce energy levels. They occur naturally on earth's crust, but as a result of anthropogenic activities, they may enter in large quantities into the water habitats, causing serious damage to living things. Drinking water is considered one of the main routes of their entry into the human body and numbers of studies have been performed to examine the effects of toxic elements in surface and groundwater ecosystems [8 – 11].

Various ecotoxicological risk assessment indices have been used to evaluate the synergistic effects of heavy metals. Heavy Metal Pollution Index (HPI) and Heavy Metal Evaluation Index (HEI) are among the most widely used risk assessment indexes [12 – 14].

The aim of this research was to evaluate the water quality of Atikhisar and Alibey Dam Lakes by applying two of the most widely used ecotoxicological risk assessment indices in order to provide a summary of synergistic effects of heavy metals and by using Geographic Information System (GIS) in order to provide a visual summary of detected indices data.

MATERIALS AND METHODS

Collection of Surface Water Samples

Surface water samples were collected from the input and output locations of Atikhisar and Alibey Dam Lakes (total of 4 stations) in the dry season (end of summer) of 2022. The maps of study area and the selected stations with the coordinate information are given in Figure 1.

Element Analysis

pH values of surface water samples (one liter) were set to 2 by means of adding 2 ml of HNO3 into each. Then the samples were filtered by means of a cellulose nitrate filter (0.45 µm) and their volumes are made up to 50 ml with ultrapure water. Toxic element levels were determined by using an ICP – MS device (Agilent 7700 xx) in Thrace University in an international accreditation certificated laboratory and the element analyses were recorded as means of triplicate measurements (TS EN / ISO IEC 17025) [15].

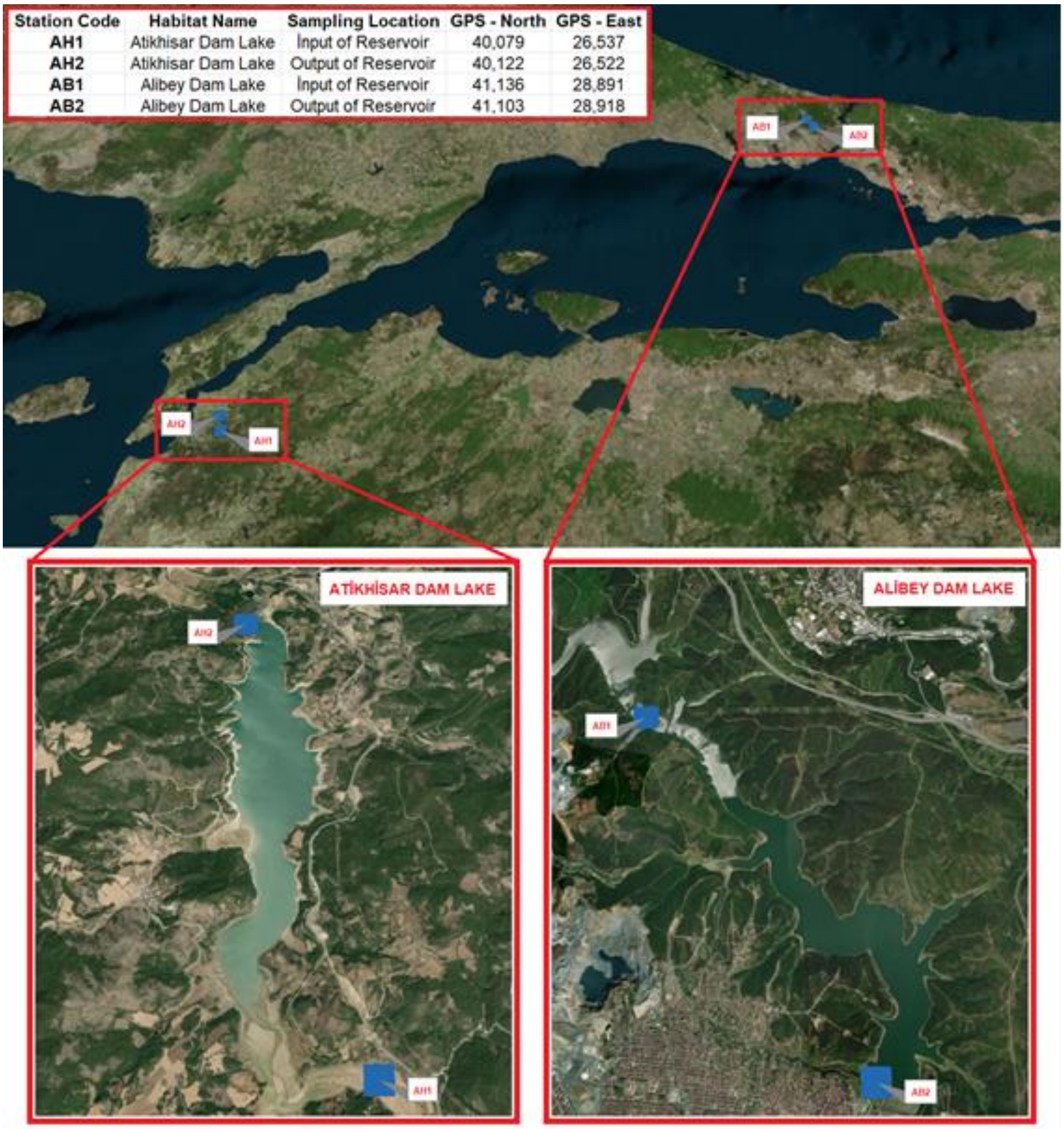

Figure 1. Study area and selected stations

Calculation of Risk Assessment Indices

Heavy Metal Pollution Index (HPI) (formulas 1 and 2) and Heavy Metal Evaluation Index (HEI) (formula3) are being calculated according to the following formulas:

$$HPI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

$$Q_i = \sum_{i=1}^{n} \frac{M_i}{S_i} \times 100 \quad (2)$$

$$HEI = \sum_{i=1}^{n} \frac{H_C}{H_{MAC}} \quad (3)$$

“Qi” is the sub – index of the toxic element, “Wi” is the unit weight of the ith parameter, “Mi” is the monitored values of toxic metals, “Si” is the standard values of the parameter [16] and n is the number of parameters considered. Water quality ratings for applied HPI are given in Table 1.
"Hc" is value observed for each parameter and "Hmac" indicates the value of maximum admissible concentration (MAC) for each parameter [16]. Water quality ratings for applied HEI are given in Table 1.

Table 1. Water quality ratings for indices

Value	Rating of Water Quality	Usage Possibilities
Heavy metal pollution index (HPI)		
< 100	Low heavy metal contamination	Suitable
> 100	High heavy metal contamination	Not suitable
Heavy Metal Evaluation Index (HEI)		
< 10	Low contamination	Suitable
10 – 20	Medium contamination	Not suitable
> 20	High contamination	Not suitable

RESULTS AND DISCUSSION

Monomial and multinomial risks according to HPI and HEI for the water of Atikhisar and Alibey Dam Lakes were calculated separately for all the investigated stations. The monomial index scores of all the investigated locations are given in Figure 2. The results of multinomial index scores of all the applied ecological risk assessment indices are shown in Figure 3 as GIS based distribution maps.
According to the results of applied ecotoxicological indices, water of the Atikhisar and Alibey Dam Lakes posed “low heavy metal contamination” in terms of HPI and “low contamination” in terms of HEI.
According to monomial regulators of HPI, the risks of investigated toxic elements may be sorted as As > Hg > Sb > Cd > Ni > Se > Ba > B, in general. According to monomial regulators of HEI, the risks of investigated toxic elements may be sorted as As > Ba > Hg > Ni > B > Sb > Se >Cd, in general.
Arsenic is a potentially toxic and carcinogenic element. Many industrial processes contribute to arsenic contamination of the environment. Exposure of arsenic may cause many of health problems for human [17 – 21].
In the present research, although the multinomial results of applied ecotoxicological indices were below the critical limit levels, arsenic was found as the most critical element among the investigated toxicant, in general. Agricultural applications and generally applied monocultural practices conducted around the reservoirs is thought to be the main cause of these detected relatively high arsenic risk.
According to the results of multinomial HPI and HEI, the risks of investigated reservoirs may be sorted as Alibey Dam Lake > Atikhisar Dam Lake, in general. The fact that Alibey Dam Lake is located in a highly populated and industrially developed region like İstanbul is thought to be the main reason for detected higher HPI and HEI values than Atikhisar Dam Lake.

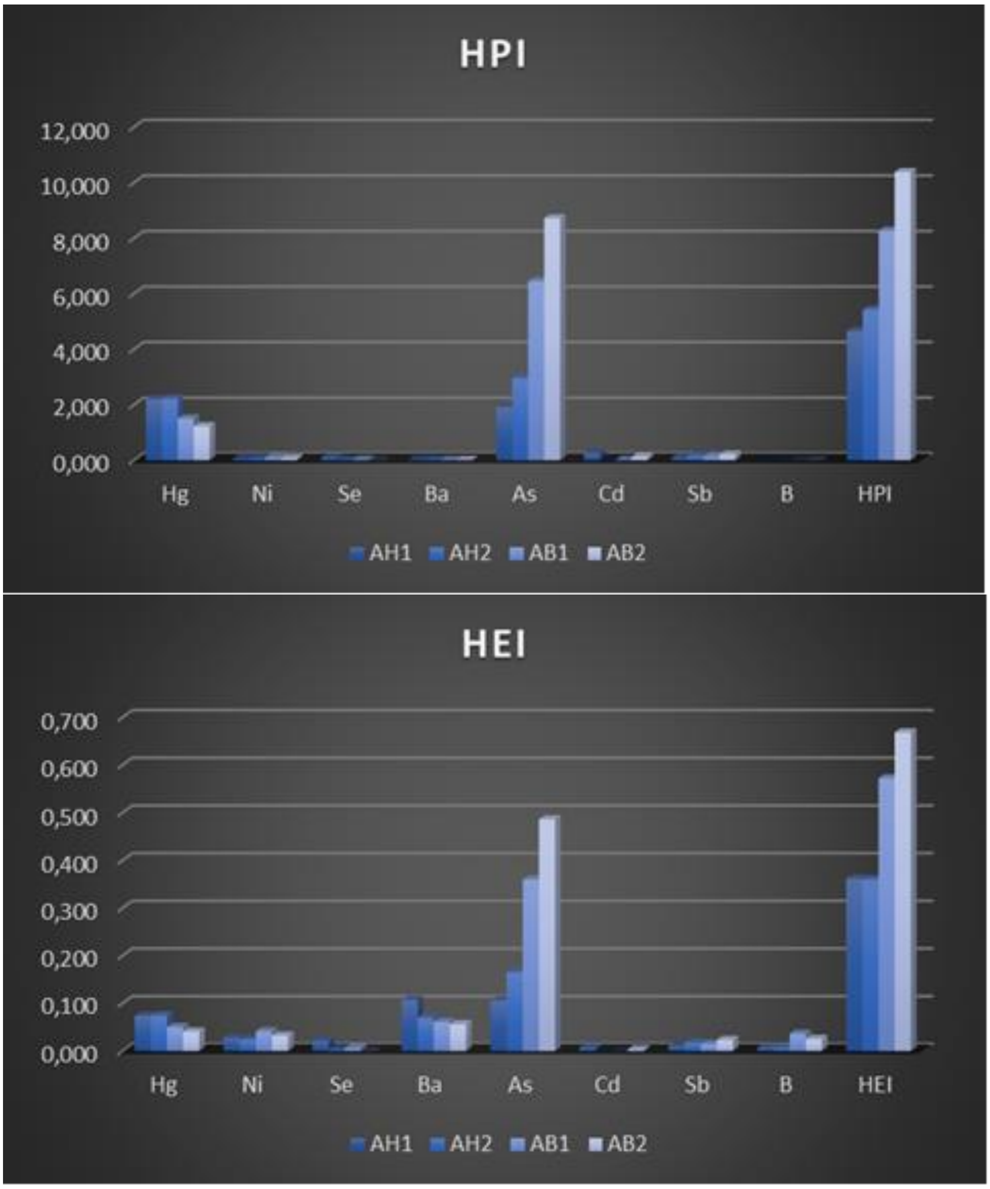

Figure 2. Monomial HPI and HEI coefficients for heavy metals

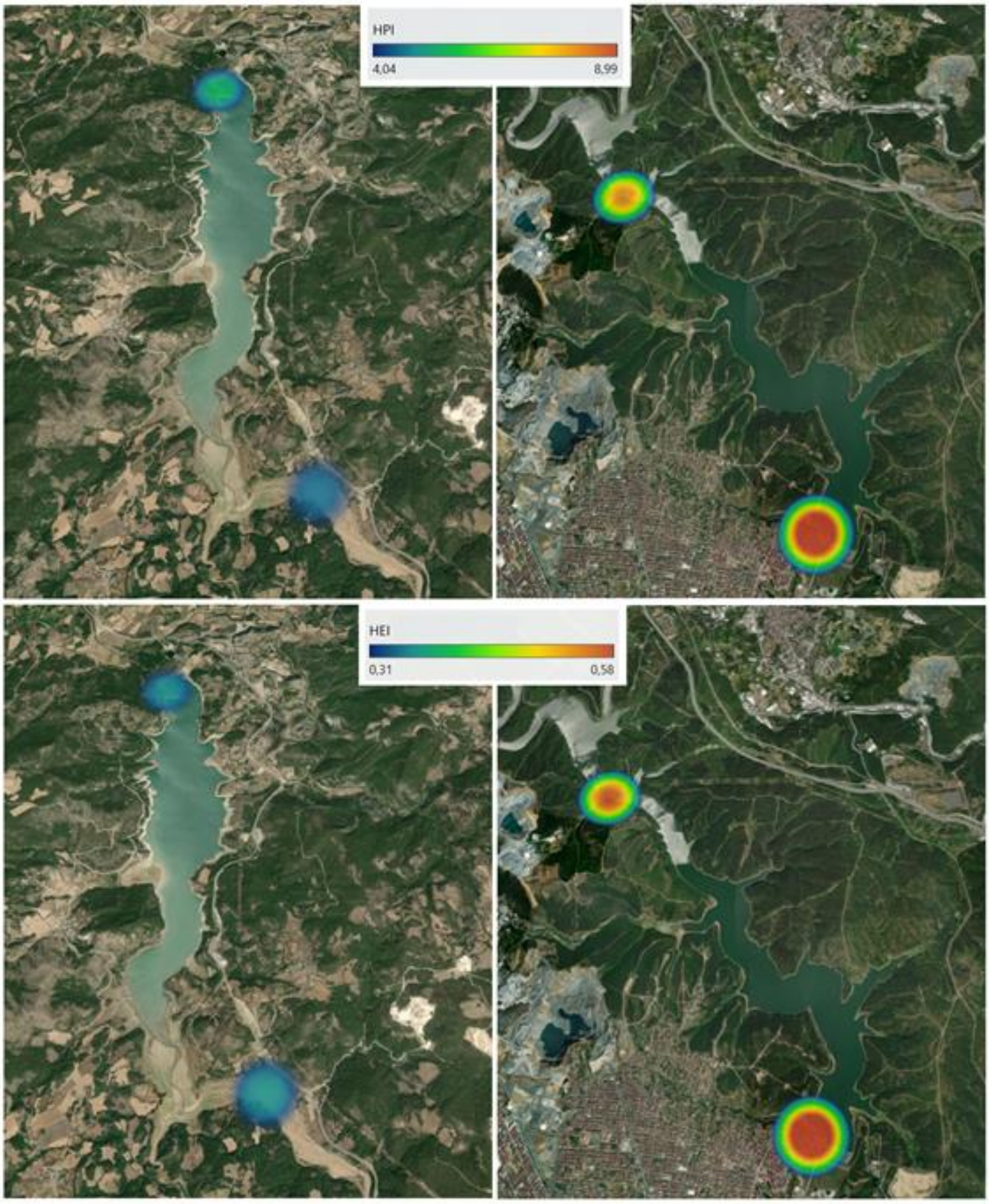

Figure 3. GIS maps of multinomial results of applied HPI and HEI

In order to evaluate the heavy metal contamination status in waters of the Atikhisar and Alibey Dam Lakes, the levels of calculated HPI and HEI values obtained from the current research were compared with those reported by previous investigations in Türkiye (Table 2).

The average levels of HPI and HEI values detected in the water of Atikhisar Dam Lake in the current research were lower than all the compared freshwater ecosystems. The average levels of HPI and HEI values detected in the water of Alibey Dam Lake in the current research were lower than detected in the waters of Pond and Lakes of Thrace Region, Gala Lake, Çorlu Stream and Ergene River, while they were higher than detected

in the waters of Atikhisar Dam Lake, Dam Lakes of Thrace Region, Meriç River and tributaries – groundwater resources of Ergene River Basin [22 – 25].
These findings revealed that the levels of heavy metal contaminations of different fluvial and lacustrine surface water and groundwater habitats varied significantly as a result of anthropogenic activities and natural sources.

Table 3. Comparison of HPI and HEI values in current study with other aquatic habitats

Aquatic Habitat	HPI	HEI	Reference
Atikhisar Dam Lake	5.04	0.36	Current Research
Alibey Dam Lake	9.32	0.62	Current Research
Thrace Region Lakes	17.83	0.90	[22]
Thrace Region Reservoirs	7.06	0.40	[22]
Thrace Region Ponds	10.47	0.60	[22]
Gala Lake	55.98	3.50	[23]
Çorlu Stream	22.60	3.45	[24]
Meriç River	5.06	0.36	[25]
Ergene River	13.18	1.43	[25]
Ergene River Basin Tributaries	8.31	0.77	[25]
Ergene River Basin Groundwater	8.32	0.53	[25]

CONCLUSION

In this study, some widely used toxic element risk assessment indices were used to evaluate and compare the water qualities of Atikhisar and Alibey Dam Lakes. As a result of this study, the selected sampling locations on the Atikhisar Dam Lake were found as relatively less contaminated, while the selected sampling locations on the Alibey Dam Lake were found as relatively more contaminated, in general. It was also determined that arsenic was found as the relatively most critical toxicant among the investigated heavy metals. It was also determined that all the investigated reservoirs found as "Low heavy metal contamination" and "Suitable for consumption" in terms of applied HPI and "Low contamination" and "Suitable for use" in terms of applied HEI. In line with the data of the current investigation, in order to maintain the sustainability of these significant dam lakes, which is of great importance especially for the people living in the region, it is recommended to continuously monitoring the accumulation levels of heavy metals in water, sediment and biotic factors.

Acknowledgments

The author would like to thank to Trakya University Scientific Research Projects Unit for the financial support to this research (project number: 2022/168).

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POSSIBILITIES AND PROBLEMS FOR THE INTEGRATION OF POINT CLOUDS FROM DIFFERENT SURVEY METHODS

DOI: https://doi.org/10.18509/GBP23243g
UDC: 528.74:528.93(436)

Josef Gspurning
Wolfgang Sulzer
Institute for Geography and Regional Sciences, University of Graz, **Austria**

ABSTRACT

With the increasing use of 3D point data in various fields of environmental research (e. g. monitoring of landslides or debris slides), questions about the acquisition of the data material, the quality of the data and, thus their integrability into an already existing geodatabase become more and more important. In the present work, an attempt was made to combine point clouds from a wide variety of survey methods into an overall data set of the highest possible quality. On the one hand, terrestrial laser scans generated by Riegl VZ-600 2018 and, on the other hand, image data acquired by UAV flights (DJI Phantom IV,) during the same field campaign served as a basis for this. Reconciliation and combination of these (partly unregistered) raw data sets was performed using Riscan Pro and Agisoft and CloudCompare software, respectively, assessing the quality of the product by comparing it with official ALS of Slovakia or by defining a maximum allowable Root Mean Square Error (RMSE). It was shown that a subsequent integration of 3D data from different sources can certainly lead to satisfactory results, although the problems of the methodology (unfavorable behavior of larger water surfaces, surface changes between the recording times of TLS and ALS, shaded areas in the TLS, ...) became obvious.

Keywords: terrestrial laser scanning, unmanned aerial vehicle, structure from motion, point cloud processing, High Tatra Mountains

INTRODUCTION

One of the most widespread and, in view of the advantages arising from it, rightly often used areas of point clouds acquired terrestrially or airborne is the application of this data material in disaster control research. Regardless of whether it is the simulation of flood scenarios, the inventory and documentation of mass movements or the monitoring over a certain period of time [1,2], the possibility of acquiring large amounts of geodata comparatively quickly and almost area-wide. Apart from the necessary and comparatively large expenditures in the form of hardware and software costs, but also in the form of the necessary expertise of the acquisition team, the difficulties and problems that can occur, especially in extreme investigation areas such as high mountain areas, are often underestimated when planning the field work. Such a scenario, in which external influences and problematic conditions have seriously jeopardized the results of a carefully planned measurement campaign, serves as the background for the project presented here. The Velická dolina study area is located in the eastern part of the High Tatras about 10 km northwest of Poprad in the immediate vicinity of the lake of the same name (Velické Pleso) situated at an altitude of 1665 m above sea level. The main axis of the valley is about six kilometres long and extends from the road Cesta Slobody to the mountain

Velický štít on the main ridge of the High Tatras between Zadný Gerlach and Východná Vysoká. The valley covers an area of about 5.7 km². The refuge, today mountain hotel Sliezsky Dom, was built in 1895 and is situated at the southern end of Velické Pleso. Morphologically, it is a part of a map staircase, which is important from the point of view of elevation, because the area is framed by steep rock walls both laterally and inwards from the valley, and therefore large areas of the terrain are neither accessible nor visible. As a result of this over-division of the relief and its exposed position, the area is also characterized by large-scale mass movements that manifest themselves in the landscape in the form of mighty debris and rubble fans (Fig. 1).

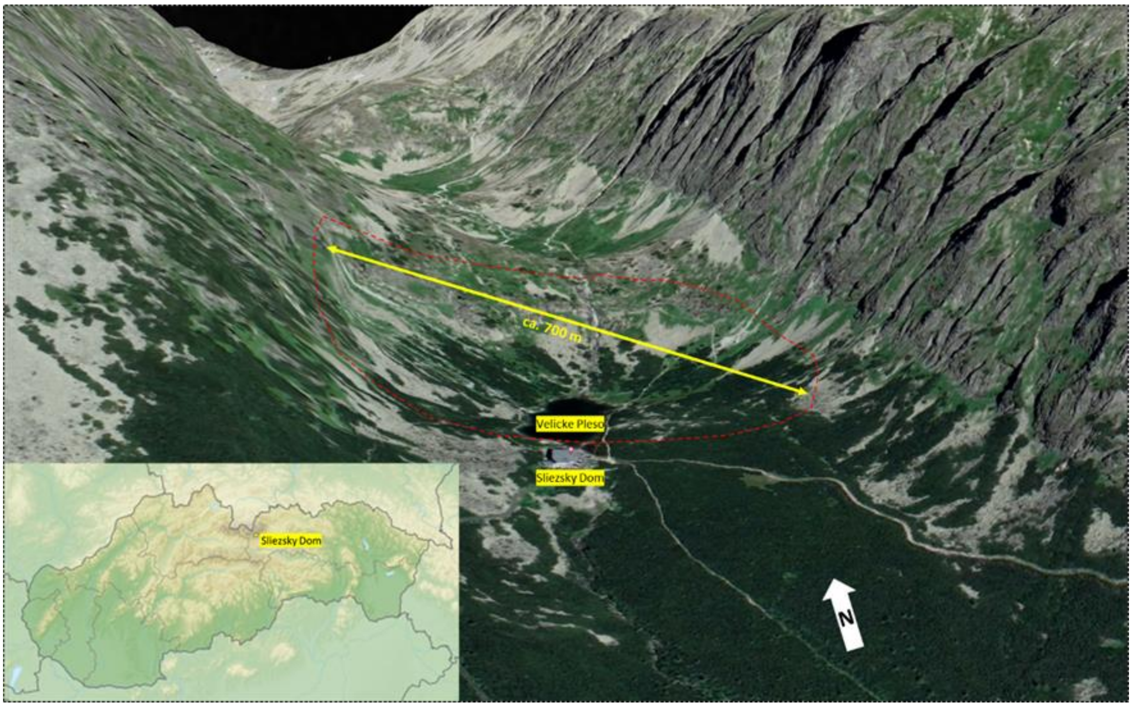

Figure 1. Location and relief of the Velické Pleso/Sliezsky Dom investigation site. The red dashed line delineates the area covered by TLS and UAV measurements. Source: Google Earth, modified by the author.

This characteristic - poor accessibility combined with shadowed areas - suggested the use of a combined land/airborne acquisition strategy. In this way, the advantages of both survey methods are combined and as a result, high-resolution scans could be obtained in addition to the texture information of the photogrammetric drone images. Of course, this requires careful planning of the work package and their interdependencies as well as the appropriate execution.

Figure 2. View over the western flank of Velické Pleso towards Kvetnicová veza (2433 m). Source: Sulzer, 2017.

The photograph (Fig. 2) documents the characteristics of the study area. At the lower part of the rocky, steep terrain (ca. 1800 m), partly active debris cones or debris channels emerge from the incised flanks, which then gradually change into shallow mostly inactive debris fans. Towards the shore of the lake (ca. 1660 m) the episodically water-bearing gullies change into small alluvial fans. The typical vegetation here is patches of leghorn (Pinus mugo), which is difficult to walk on and is interspersed with herbaceous vegetation, especially in the lower areas. At the upper edge towards the rocky areas there are late alpine grass heaths.

The starting point of the present study was the attempt, envisaged at the beginning of 2018, to investigate more precisely the development of mass movements in the vicinity of the lake; it should be emphasized in this context that, at the time of the project planning, no DTM was available from the official side that would have met the requirements of the study. The data material used in this work with the resolution of 1 m originates from aerial surveys that took place between 7.8. and 8.8. 2018. Not least in consideration of the coarse-blocky nature of the terrain surface, the goal of the campaign was to create an elevation and surface model that would be significantly better in terms of resolution than the data available up to that point.

The equipment used essentially comprised 3 components, with the location of the required ground control points, reflector and scanner sites being carried out using dGPS in the form of a kinematic RTK solution. The terrestrial scans were performed using a Riegl Z620; this system is a class 1 rotating laser with a maximum range of 2000 m which - with a field of view of 80° by 360° - is capable of acquiring about 11000 points per second. The beamwidth spread is 0.15 mrad (equivalent to 15 mm expansion per 100 m), the minimum possible angular step width is 0.004°. The latter corresponds - in case of an average object distance of 700 m - to a theoretical point spacing on the object of about 5 cm [3]. For the image data acquisition from the air, a flying drone was used. The naturalized term Unmanned Aerial Vehicle (UAV) is used for this purpose in this paper. This is also known by names such as Unmanned Aerial System (UAS), Remotely Piloted Vehicle (RPV) [4]. The above terms are often used as synonyms. UAVs provide a platform equipped with a photogrammetric measurement system, including a small or medium still video or video camera, thermal imaging or infrared camera systems, airborne LiDAR systems, or a combination thereof [5]. A DJI Phantom 4 was used in Velické Dolina because of its robust and compact design and its ability to remain stable in flight despite its light weight of 1380 g, even in the strong winds often prevailing in the study area. This advantage is achieved by a new design for the time with improved aerodynamics (the Quest 200 fixed-wing aircraft, which was also intended for use, was not used on the one hand because of the constriction of the cirque area and the gusty winds). The DJI Phantom 4 is a Quadro copter with a 4K camera and allows a flight time of about 28 minutes by using a battery with a capacity of 5,350 mAh. The image format can be selected between RAW and JPG images, whereby the JPG formats are sufficient for further processing in Agisoft Metashape.

With regard to the objective of the research project (recording of the slope areas around Velické Pleso classified as morphodynamically active as a basis for future monitoring projects), the work plan included a complete and detailed recording of the study area by means of laser scanners; in addition, selected areas were to be covered by means of UAV flight in order to avoid data gaps due to shadowing and to increase the data density. The RTK-based measurement of scanner and reflector locations as well as the location of about 50 ground control points served as the basis for the georeferencing of the data obtained in this way. As already indicated, however, unforeseeable technical difficulties with the equipment made it necessary to deviate from this plan. In detail, an unspecified error in the scanner's cabling caused problems with the power supply (and thus subsequently with the device control), so that instead of recording larger, contiguous areas, the focus had to be placed on recording smaller sections of the terrain. This approach made it possible to control the loss of data due to unforeseen interruptions of the scanning process to a certain extent, but it also meant a considerable additional effort and delays in the schedule. Finally, the area was scanned from 5 scan positions with a step width of 0.017°, so that at a distance of 300 m, adequate for the purpose of the investigation, with a point spacing of somewhat more than 10 cm (at 400 m approx. 13 cm), it was possible to calculate with about 126 points on one square meter. Compared to the official Slovak DOM (which at that time was only in the flight stage), this meant that the level of detail was significantly higher. With the quadrocopter DJI Phantom 4, a total of 197 images were taken in 4 flight campaigns.

Table 1. Flight parameters for the UAV campaign Velicko dolina

flight	images/ waypoints	cover area	flight length	altitude above starting point	resolution	front overlap ratio	side overlap ratio
01	39/43	3.67 ha	708 m	100.4 m	4.3 cm	90 %	60 %
02	66/69	2,52 ha	712 m	70.3 m	3 cm	90 %	67 %
03	61/62	2,46 ha	656 m	68.3 m	3 cm	90 %	65 %
04	27/27	2.89 ha	536 m	111,7 m	4.8 cm	90 %	60 %

Since the weather was very unstable with gusty winds, the flights had to be kept as efficient and short as possible. The division of the recording into four individual flights is due to the battery capacity and the necessary safety reserves. Due to the unfavorable wind conditions, not all waypoints of the flight planning could be approached by the UAV controlled by an internal GPS either. However, the missing images could be compensated by the high front and side overlap ratio (90 % and approx. 60 %, respectively). The changing altitudes of the flights result from different starting positions in the study area. The varying flight heights result from the different relief. In steep, rocky regions, a higher flight altitude above ground was selected for safety reasons (risk of collision and winds). Despite these adversities, a geometric resolution between 3 and 5 cm and thus a target resolution of the project with 5 cm could be achieved.

As a result of the previously described collection process, three types of data were created - corresponding to the different acquisition procedures: Unfortunately, the analysis of the scan-relevant control points acquired by means of dGPS showed an unsystematic error for reasons no longer comprehensible at the time of the analysis, which manifested itself in a lateral offset of the position of scan or reflector positions in the order of magnitude between 1.5 m and 3.5 m.

From a huge number of TLS scans, including overview scans with a step size of only 0.2° and about 750,000 data points each, 5 distinct point clouds with a step size of 0.017° and between 22 million and 45 million points (file size: 400 - 700 Mbyte) were selected for further processing. Due to the favorable distribution of the scanner locations around the lake, a sufficient overlap and a significant reduction of the shadowing areas could be achieved. Unfortunately, however, the problems described above hampered not only precise real-world location of these inherently high-quality data but also (due to the lack of accurate measurements of the reflectors) efficient scan-to-scan linking of the individual point clouds.

METHODS

As a consequence of the described problems with the dGPS data, the use of these measurements was completely abandoned in the further processing of the data; instead, recourse was made to the official aerial photo material, the high quality of which (RMSExy = 0.20 m) was sufficient to be able to carry out the necessary rough localizations with an accuracy of +/-30 cm with the aid of the photo documentation created during the measurement campaign and in this way to convert the point clouds from the SOCS (scanner own coordinate system) into a projected system and thus to create the basis for further processing. Only after this step could the generation of a high-resolution surface model be tackled; the concept for this is based on the attempt of an error correction of the raw data by comparison with the official data. This way seems to be possible insofar as both the DTM 5.0 and the DSM 1.0 or the underlying ALS point cloud have sufficiently strict quality criteria. The point cloud data intended for comparison have an absolute vertical accuracy of less than or equal to 0.15 m (related to ETRS89 ellipsoidal heights) or an absolute positional accuracy of 0.30 m (related to ETRS-TM34); for DTM 5.0, these values are less than 0.20 m and 0.25 m, respectively [6]. Thus, a fit of the TLS/UAV data into the supra-regional DSM seems to be within the realm of possibility.

In the next step (data pre-processing), a rough registration of the official ALS data to the TLS point clouds was performed. This was done in the form of a point-to-point transformation over clearly identifiable points in the terrain (ridges, rocky peaks or hiking

trails or the lake shore). At the end of this process, there is still a relatively large RMS error of about 13 m, but this value is not too important insofar as this step only served as a preparatory measure to reduce the processing time for the fitting process that was later carried out in an iterative manner. In addition, it should be noted here that certain deficiencies in the TLS data sets were already apparent at this stage, which had the potential to negatively influence the fitting quality. Particularly noticeable was the discrepancy in the water surface of the lake, which had been appropriately corrected in the ALS, while in the TLS point clouds it naturally exhibited reflections, resulting in the need to mask the water surface area for the calculations. Moreover, backscatter effects occurred in the TLS scans, which also had a negative impact on the fitting quality; the latter were minimized by applying a filter whose parameterization (taking into account local maximum possible height differences of the relief, vegetation height, ...) did not pose too many problems. Finally, the question had to be clarified to what extent the inclusion of TLS areas located further outside the study area should be included in the calculations. Since it could not be estimated with sufficient certainty at this point in time whether these data would have a rather positive or rather negative effect on the calculation, it was initially decided not to remove these scans. After the removal of the errors just described, the RMSE could be reduced to 2.28 m, so that it was possible to speak of a sufficiently stable starting point for the next adjustment process. This iterative closest point algorithm (ICP - algorithm) for fine registration of points, lines, polygons and TINs), first presented by Besl and McKay [7], consists essentially of 4 steps, the determination of neighbouring point pairs from the point clouds to be compared, the calculation of the general transformation rule, the execution of the transformation of the point cloud to be registered on the basis of these results and the iterative repetition of this procedure until a defined termination criterion is met. As a prerequisite for the practical applicability of the procedure, as already mentioned, the rough matching of the non-referenced scan to the reference point cloud and its overlap are sufficient, although a merely partial overlap of the two areas generally does not have a serious impact on the result. Thus, even point clouds that - if referenced - have only a relatively small overlap (i.e., a low final overlap value) can be processed. The central element of quality control in this process is the RMSE, whose change is measured after each loop pass. Accordingly, it is not surprising that, in addition to the brute force method (i.e., by a priori definition of a certain number of passes), the magnitude of this change can be used as a termination criterion. In other words, the continuous improvement process is terminated when the RMSE decrease falls below a predefined minimum amount. In the course of time, the basic concept has been revised or refined, especially with respect to the selection of the corresponding points, so that, for example, far outlying points are disregarded (robust ICP) [8], the selection of the correspondences is optimized by using improved data structures (k-tree) [9, 10], or the reduction of the search space via pyramid levels [11, 12]. In the present case, the different acquisition and processing methods of the data or the possibly resulting scale differences were considered insofar as the software was allowed to adjust any scale differences. Furthermore, a random subsampling routine with a threshold value of 50000 points was defined to be able to process the relatively large point clouds quickly; in addition, the speed of the transformation was also optimized regarding the behaviour towards statistical outliers (due to noise or unevenly distributed points).
The local adjustment and the determination of the point distances in the model is done in principle either by defining n comparison points to be considered for the calculation or by using a local reference surface; the aim of this Local Modelling is that it should prevent

that the calculation of the point distances is based only on the distance to the n nearest neighbours (Hausdorff distance algorithm), which proves to be disadvantageous especially for comparison point clouds with low density or with "holes" in the dataset [13]. The concept of "local modelling" tries to assume the real surface around the closest point to get a better estimate of the "real" distance. Three concepts are available for this purpose: the use of the plane of least squares of deviation, a 2D1/2 triangulation of the surface sought, or the height function (actually a 6-parameter quadratic function, though both mapping fidelity and computational cost increase in that order. Because of its versatility, the quadratic model was used in the present study, although arguments could have been made for the triangulation method given the surface configuration in the study area.

Due to the sometimes-significant differences in radiometry between the images and variations in geometric resolution, the processing of the data is relatively complex and sometimes necessitates extensive processing steps [14]. According to Colomina and Molina [15], UAV data are also characterized by unstable camera geometries, irregular aerial image block structures (significant deviation from nadir acquisition, highly variable image scale, changing image coverage, and varying flight altitude within a strip), and sometimes large geometric and radiometric variations. This is particularly noticeable in the high mountains with high relief. UAV data have, among others, special unstable camera geometries, low radiometric resolution, etc., which lead to their limited analysis in classical photogrammetric software packages. Structure from Motion (SfM) is a cost-effective and user-friendly photogrammetric technique for obtaining high-resolution datasets at various scales [16]. According to it, the basic principle of SfM method is to derive 3D information from overlapping (stereoscopic) images. The image overlaps of the UAV images are usually very large for the SfM method, ranging from 60-80 %. The software used in this work is Agisoft Metashape Professional. This software allows the processing of RGB or multispectral camera images, into the form of point clouds, georeferenced orthomosaics and digital elevation models. The software has a linear project-based workflow, which is user-friendly even for non-experts. Smith et al [17] give an overview of a typical SfM workflow (Fig. 3).

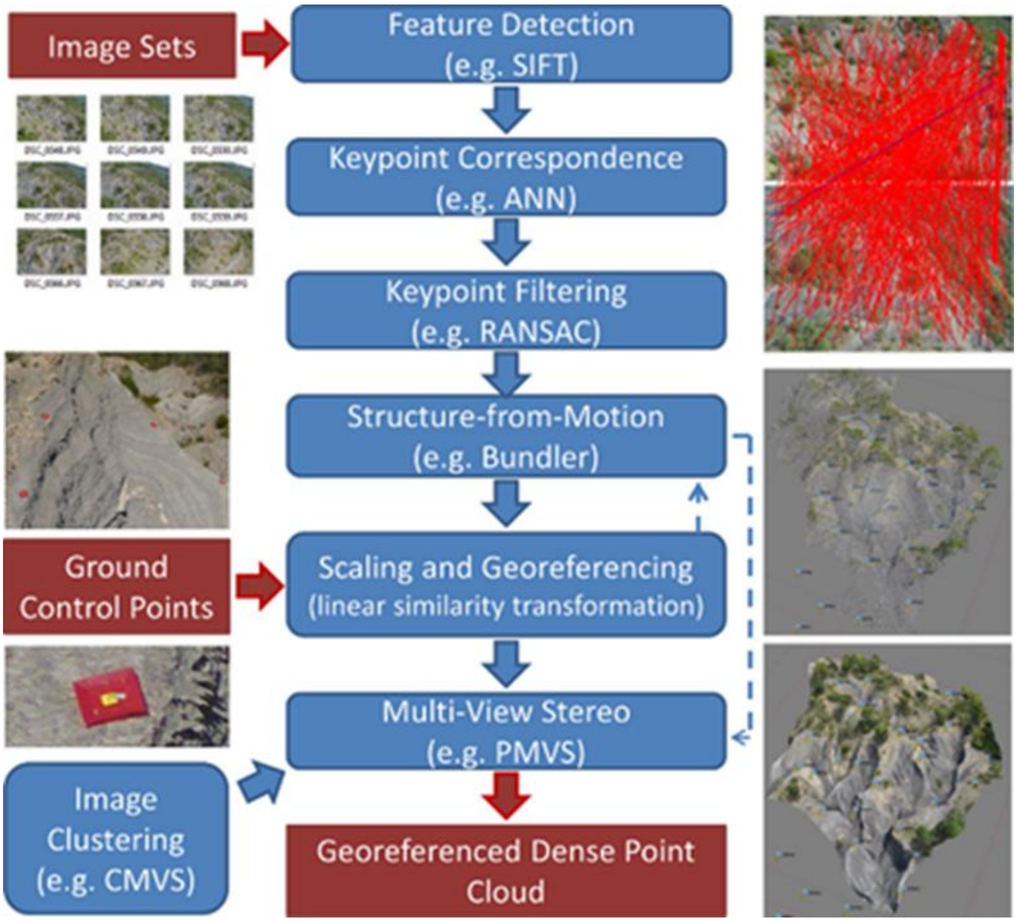

Figure 3. Typical workflow in the production of georeferenced dense point clouds from image sets and ground control points. Inputs and outputs are shown in dark red. In the top right, as a demonstration, matches determined to be valid are shown in red, while matches determined to be invalid are given in blue [17].

This workflow is independent from the used software as well as from the used acquisition platform, because in commercial software packages, like the software used in this work, the exact workflow within the software or single processing steps is not known. The processing of UAV image data in Metashape includes the following main steps: loading photos into Metashape - inspecting loaded images, removing unnecessary images - aligning photos - building dense point cloud - building mesh (3D polygonal model) - generating texture - building tiled model - building digital elevation model - building orthomosaic- exporting results [18]. Some Metashape functions like exporting digital elevation models are only available after the coordinate system has been defined. The software supports setting a coordinate system based on ground control point coordinates (GCP's) and/or camera coordinates. In both cases, the coordinates can either be loaded from the external file or entered manually. Unfortunately, the ground control points (GCP) surveyed with the dGPS could not be used for georeferencing either. Thus, only the camera positions supported by points measured from the official orthophotos could be entered.

RESULTS AND DISCUSSION

As already shown in the presentation of the applied methodology, the quality of the fit - documented by the RMSE to the ALS model - could be increased significantly (to RMSE equal or less than 0.51 m). After a more intensive post-processing of the TLS scans in the form of an improved backscatter filtering but also by masking the originally still included peripheral areas of the scans (comparative calculations had shown their low relevance for the local fitting quality), the RMSE value for the individual point clouds could be reduced to about 10 cm (Fig. 4).

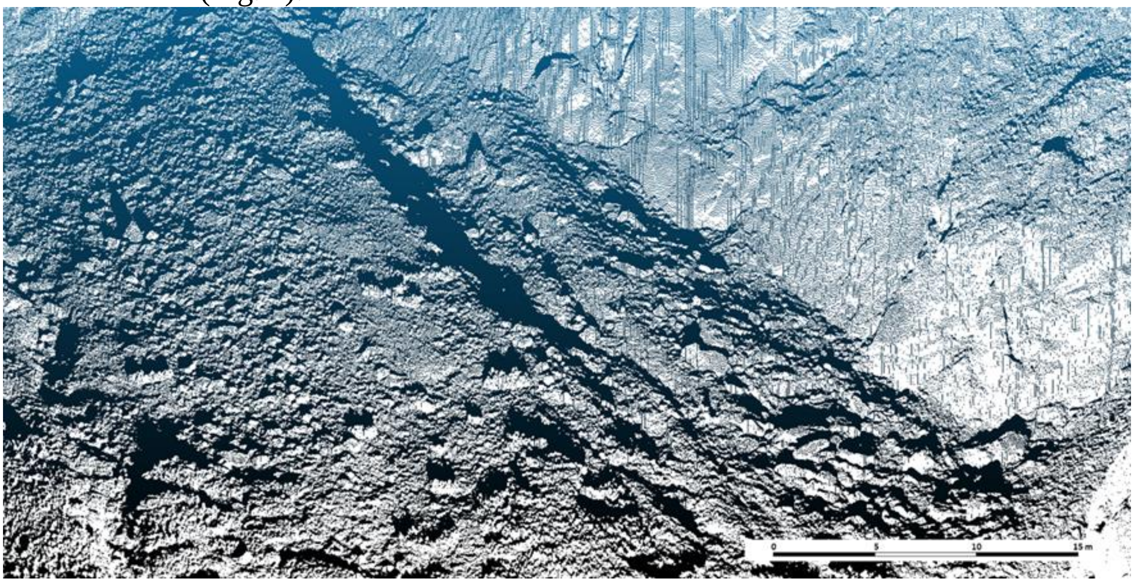

Figure 4. Although the resulting point cloud is too complex to be shown here in more detail, the picture clearly shows two important aspects of the result of the integration process: on the one hand, the high point density/detail fidelity of the surface created in this way, and on the other hand, the partially large, shadowed areas.

Thus, the originally set goal can be considered achieved for the time being, especially since the other potential sources of error are of such a more complex nature that they can only be briefly touched upon in this paper. Although the vegetation in the study area consists almost exclusively of slow-growing cold-resistant scree (Pinus mugo ssp. mugo) or alpine turf, a minimal deviation between ALS and TLS cannot be completely excluded. However, the former were relatively easy to identify and, if necessary, to separate out due to the approximately equal stand growth height. That being said, the steep slopes surrounding the immediate study area could have an impact on the results in that they are the source of large-scale, relatively dynamic debris piles. This coarse blocky material could be responsible for the fact that - even with very small lateral movement - the overturning of a block can provide for recognizable changes in the surface appearance. Finally, differences in the recording systems used (in terms of footprints, recording angles, equipment differences, etc.) can also have an impact on the calculation results. Finally, the attention should also be directed to the further processing of the produced data set. It is understandable that the process presented here directs its focus only to the preparation of the data material, which will most likely be analysed and visualized by users in other working environments such as GIS. In most cases, therefore, conversion to other data models will be necessary. Whether raster (grid) or vector (TIN) models are more advantageous in this case is primarily dependent on the problem or the analysis tools required for it. In any case, the problem of data gaps will again come to the fore in these considerations and will have to be taken into account in the further processing steps. Remote sensing or SfM provides high-resolution orthophotos and surface models (DSM).

Figure 5. Part of the Orthophoto from UAV (2017) with a resolution of 5 cm (left) and (right) Orthophoto from 2019 with a resolution of 25 cm. Source: https://zbgis. skgeodesy.sk/

Fig. 5 presents a comparison between the 2017 orthophoto (5 cm resolution) produced by SfM and the 2019 official orthophoto (25 cm). The level of detail of the terrain information is clear from the plot. This allows the detection of macroscopic terrain structures and in repeat flights, their change. In addition, changes in ground cover, especially vegetation, can be detected and displayed with relatively little effort.

SUMMARY

Based on the research questions that preceded this work, the following results can be summarized at this point: The fundamental question about the basic feasibility of the correction procedure for erroneously acquired data presented here can be answered positively, whereby in the present case the almost simultaneous collection of the official ALS data proved to be very advantageous. The usefulness of the data, which has been greatly improved in quality, is definitely given in view of the significantly higher sampling rate of the TLS scans, but it should not be concealed that this condensation of the point clouds - caused by the special characteristics of earthbound laser scanning as well as by the scanner positions, which are not optimally distributed for the given reason - can only be guaranteed for selected areas of the terrain. The answer to the question of the usefulness of the improved data therefore depends to a large extent on the extent to which shadowed areas or areas not detectable by the TLS are of importance for intended analyses; provided that the same scanner locations are used again for subsequent observations, these data could, for example, be used very well for monitoring landslides. Both the high-resolution orthophoto generated from UAV flights and the surface model can be used for the sensitive high-mountain region as an important data basis for changes in small subareas. Repeat flights allow the generation of spatial changes (e.g. movement of larger blocks by mass movements or by fluviatile processes.). The strengths in the use of UAV data lies in the acquisition of data with high geometric resolution, the high point density and regularity of the derived point cloud, favourable or variable recording perspective for steep mountainous regions. They are flexible and can be used even in continuous cloud cover. The argument of the flexible applicability of UAVs has to be qualified by logistical limitations (availability of personnel and material), meteorological conditions (e.g. strong wind) and legal aspects.

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APPLICATION OF HEAVY METAL POLLUTION INDEX AND HEAVY METAL EVALUATION INDEX TO EVALUATE THE WATER QUALITY OF ÇOKAL DAM LAKE (TEKIRDAĞ, TÜRKIYE): A GIS BASED ASSESSMENT

DOI: https://doi.org/10.18509/GBP23255t
UDC: 528.88.06:627.81]:[628.193:546.4/.6(560)

Cem Tokatli
Trakya University, Evrenos Gazi Campus, Edirne, **Türkiye**

ABSTRACT

Dam Lakes are artificial stagnant freshwater ecosystems built for various purposes such as irrigation and drinking water supply and flood protection. However, over the years, they can become unusable as a result of various factors such as pollution, sedimentation and excessive use. Çokal Dam Lake is one of the most important dams in the Thrace Region. It was built on the Kocadere Stream between 1997-2002 for irrigation and drinking water supply in the Tekirdağ Province. In this study, surface water samples were collected from the Çokal Dam Lake (2 locations), Aksakal and Çayırlar Streams that are feeding the reservoir and the Kocadere Stream before it falls into the Saros Bay at the output location of the dam in the rainy season (autumn) of 2020. Chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd) and lead (Pb) contents were determined in the collected samples, and the water quality of investigated locations were evaluated by applying some ecotoxicological risk assessment indices. Also Geographic Information System (GIS) was used to provide a visual summary of the applied indices.

Keywords: Çokal Dam Lake, Water quality, Toxic elements, Heavy Metal Pollution Index, Heavy Metal Evaluation Index, Geographic Information System

INTRODUCTION

Toxic metals enter the fluvial and stagnant surface water bodies through industrial or domestic wastewater and surface runoff or drainage water from agricultural lands and they may can cause significant water pollution problems [1 – 3].

Reservoirs are being constructed for irrigation, flood prevention, stream regime regulation and electricity generation. They are being constructed by State Hydraulic Works (DSI) in Türkiye and there are approximately 900 dam lakes in operation in Türkiye [3 – 5].

Çokal Dam Lake is one of the most important dams in the region, which was built between 1997-2002 for irrigation and drinking water supply, on the Kocadere Stream, in the Tekirdağ Province of Thrace Region [6, 7].

The body volume of the dam lake, which is an earth and rock body fill type, is approximately 4.065,000 m^3 and its height from the stream bed is 81 m. At the normal water level, the lake volume is approximately 204 hm^3 and the lake area is 10 km^2. While the dam provides irrigation services to an area of 10,660 hectares, it also provides 14 hm^3 of drinking water annually [6, 7].

Toxic elements such as chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd) and lead (Pb) can diminish mental and central nervous system function; elicit damage to blood composition as well as the kidneys, lungs, and liver; and reduce energy levels. Although they occur naturally on earth, they may enter in large quantities

into the air, soil and water, causing serious damage to living things and the environment as a result of anthropogenic activities. Drinking water is considered one of the main routes of their entry into the human body and numbers of studies have been performed to examine the effects of toxic elements in surface and groundwater ecosystems [8 – 11].
Especially in recent years, various ecotoxicological risk assessment indices have been used to evaluate the synergistic effects of toxic elements, and Heavy Metal Pollution Index (HPI) and Heavy Metal Evaluation Index (HEI) are among the most widely used risk assessment indexes [12 – 14].
The aim of this research was to evaluate the water quality of Çokal Dam Lake basin by applying 2 of the most widely used ecotoxicological risk assessment indices.

MATERIALS AND METHODS

Collection of Surface Water Samples

consisted fluvial ecosystem at the output of the reservoir is named as Kocadere Stream and it flows into the Gulf of Saros.
Surface water samples were collected from the Çokal Dam Lake (2 selected locations), Aksakal and Çayırlar Streams that are feeding the reservoir and the Kocadere Stream before it falls into the Saros Bay at the output location of the dam in the rainy season (autumn) of 2020. The maps of study area and the selected stations with the coordinate information are given in Figure 1.

Element Analysis

pH values of surface water samples (one liter) were set to 2 by means of adding 2 ml of HNO3 into each. Then the samples were filtered by means of a cellulose nitrate filter (0.45 µm) and their volumes are made up to 50 ml with ultrapure water. Toxic element levels were determined by using an ICP – MS device (Agilent 7700 xx) in Thrace University in an international accreditation certificated laboratory and the element analyses were recorded as means of triplicate measurements (TS EN / ISO IEC 17025) [15].

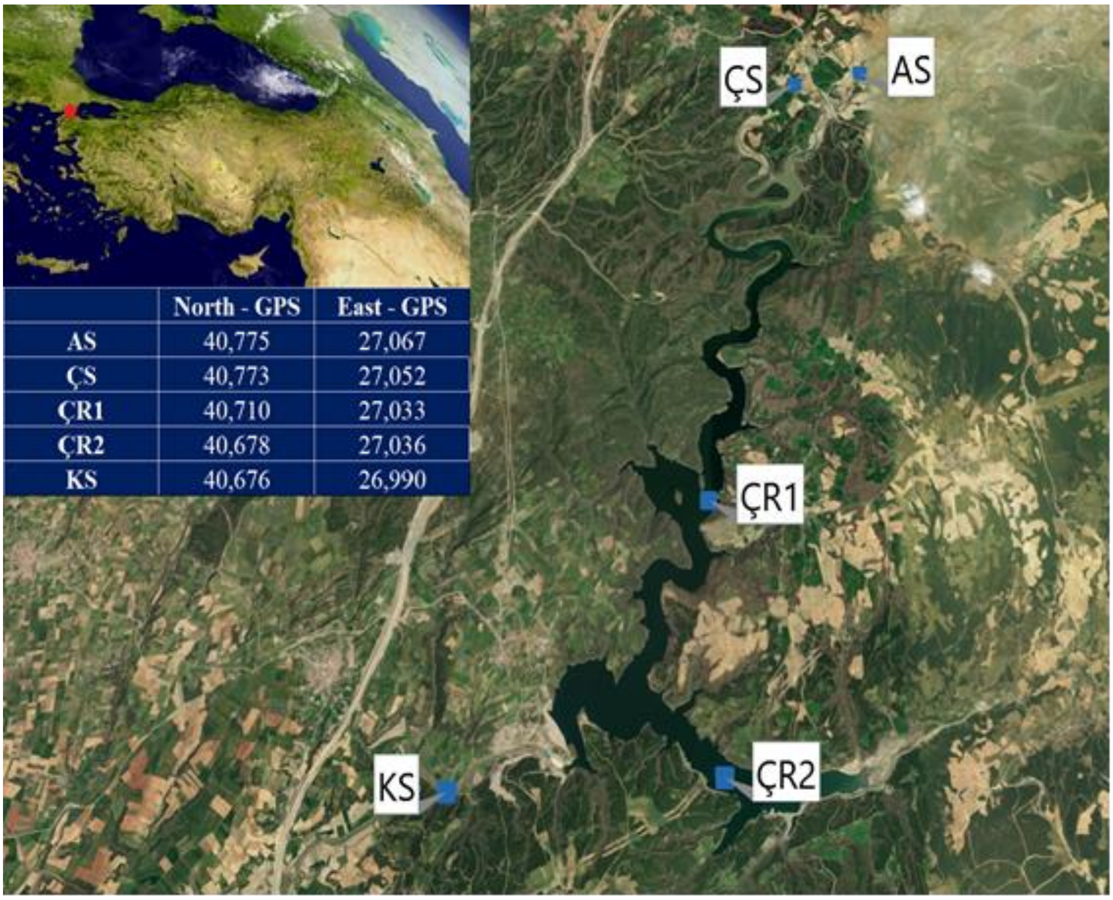

Figure 1. Çokal Dam Lake Basin and selected stations

Calculation of Risk Assessment Indices

Heavy Metal Pollution Index (HPI) (formulas 1 and 2) and Heavy Metal Evaluation Index (HEI) (formula3) are being calculated according to the following formulas:

$$HPI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

$$Q_i = \sum_{i=1}^{n} \frac{M_i}{S_i} \times 100 \quad (2)$$

$$HEI = \sum_{i=1}^{n} \frac{H_C}{H_{MAC}} \quad (3)$$

"Qi" is the sub – index of the toxic element, "Wi" is the unit weight of the ith parameter, "Mi" is the monitored values of toxic metals, "Si" is the standard values of the parameter [16] and n is the number of parameters considered. Water quality ratings for applied HPI are given in Table 1.

"Hc" is value observed for each parameter and "Hmac" indicates the value of maximum admissible concentration (MAC) for each parameter [16]. Water quality ratings for applied HEI are given in Table 1.

Table 1. Water quality ratings for indices

Value	Rating of Water Quality	Usage Possibilities
Heavy metal pollution index (HPI)		
< 100	Low heavy metal contamination	Suitable
> 100	High heavy metal contamination	Not suitable
Heavy Metal Evaluation Index (HEI)		
< 10	Low contamination	Suitable
10 – 20	Medium contamination	Not suitable
> 20	High contamination	Not suitable

RESULTS AND DISCUSSION

Monomial and multinomial risks according to HPI and HEI for the surface water resources of Çokal Dam Lake Basin were calculated separately for all the investigated fluvial and lacustrine ecosystems.

The monomial index scores of all the investigated locations are given in Table 2. The results of multinomial index scores of all the applied ecological risk assessment indices are shown in Figure 2 and Figure 3 as GIS based distribution maps.

According to the results of HPI and HEI, surface water of the Çokal Dam Lake Basin components posed "low heavy metal contamination" and "low contamination" respectively.

According to monomial regulators of HPI, the risks of investigated toxic elements may be sorted as As > Pb > Cd > Ni > Cr > Zn > Cu, in general.

According to monomial regulators of HEI, the risks of investigated toxic elements may be sorted as As > Ni > Pb > Cd > Cr > Zn > Cu, in general.

According to the results of multinomial HPI and HEI, the risks of investigated components for Çokal Dam Lake basin may be sorted as

Çayırlar Stream > Aksakal Stream > Kocadere Stream > Çokal Reservoir, in general.

Arsenic is a potentially toxic and carcinogenic element. Many industrial processes contribute to arsenic contamination of the environment. Exposure of arsenic may cause many of health problems for human [17 – 21].

In the present research, although the multinomial results of applied ecotoxicological indices were below the critical limit levels, arsenic was found as the most critical element among the investigated toxicants for all the investigated freshwater habitats in the Çokal Dam Lake Basin. Agricultural applications and generally applied monocultural practices conducted almost all around the reservoir is thought to be the main cause of these detected relatively high arsenic risk.

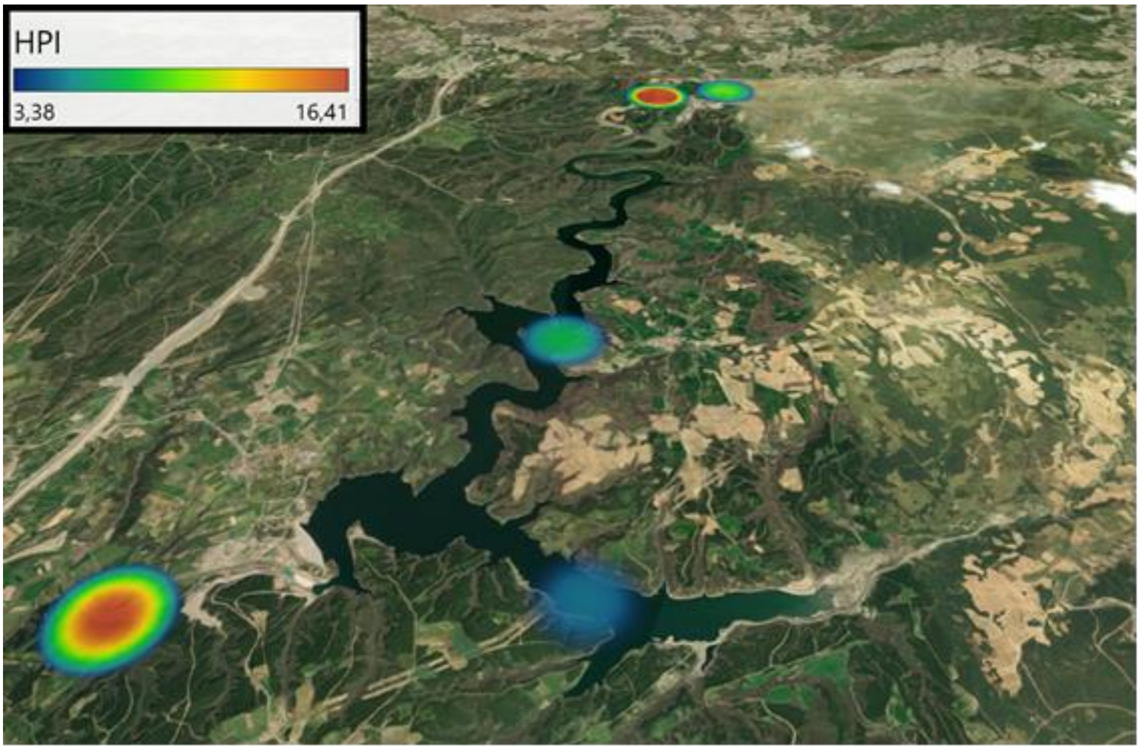

Figure 2. Multinomial results of applied HPI

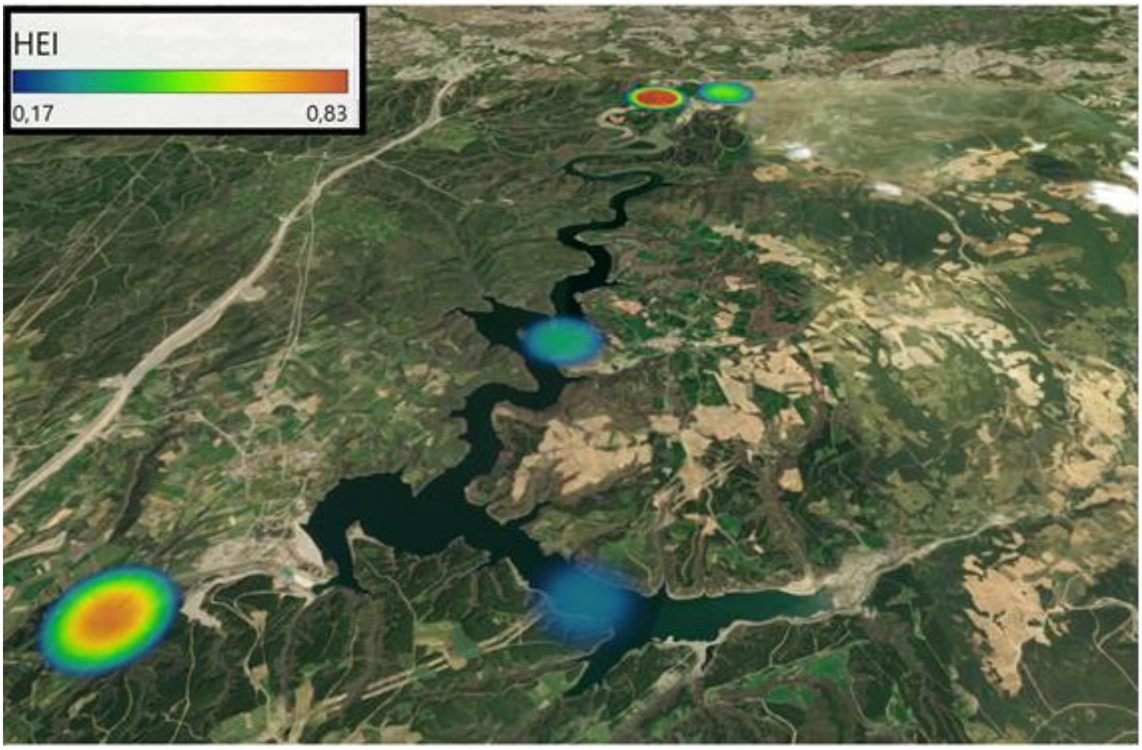

Figure 3. Multinomial results of applied HEI

Table 2. Monomial HPI and HEI coefficients for toxicants

	Monomial HPI Scores					Monomial HEI Scores				
	AS	ÇS	ÇR1	ÇR2	KS	AS	ÇS	ÇR1	ÇR2	KS
Cr	0.020	0.133	0.015	0.046	0.174	0.004	0.029	0.003	0.010	0.038
Ni	0.325	0.589	0.130	0.168	0.232	0.099	0.179	0.039	0.051	0.071
Cu	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001
Zn	0.000	0.000	0.000	0.000	0.000	0.002	0.006	0.002	0.002	0.002
As	7.661	21.987	5.314	3.019	11.935	0.333	0.956	0.231	0.131	0.519
Cd	0.477	0.376	0.764	0.594	3.225	0.010	0.008	0.017	0.013	0.070
Pb	1.059	1.554	1.192	1.251	1.284	0.046	0.068	0.052	0.054	0.056

In order to evaluate the heavy metal contamination status in waters of the of the Çokal Dam Lake Basin, the levels of calculated HPI and HEI values obtained from the current research were compared with those reported by previous investigations in Türkiye (Table 3).

The average levels of HPI and HEI values detected in the water of Çokal Dam Lake Basin in the current research were higher than detected in the waters of Ponds and Dam Lakes of Thrace Region, Meriç River and tributaries – groundwater resources of Ergene River Basin, while they were lower than detected in the waters of Lakes of Thrace Region, Gala Lake, Çorlu Stream and Ergene River [22 – 25].

These findings revealed that the concentrations of heavy metal concentrations of different fluvial and lacustrine surface water and groundwater habitats varied significantly as a result of anthropogenic activities and natural sources.

Table 3. Comparison of HPI and HEI values in current study with other aquatic habitats

Aquatic Habitat	HPI	HEI	Reference
Çokal Dam Lake Basin	12.71	0.62	Current Research
Thrace Region Lakes	17.83	0.90	[22]
Thrace Region Reservoirs	7.06	0.40	[22]
Thrace Region Ponds	10.47	0.60	[22]
Gala Lake	55.98	3.50	[23]
Çorlu Stream	22.60	3.45	[24]
Meriç River	5.06	0.36	[25]
Ergene River	13.18	1.43	[25]
Ergene River Basin Tributaries	8.31	0.77	[25]
Ergene River Basin Groundwater	8.32	0.53	[25]

CONCLUSIONS

In this research, some widely used toxic element risk assessment indices were used to evaluate the surface water quality of Çokal Dam Lake Basin components. As a result of this study, lentic habitats of the basin were found as relatively less contaminated components of the basin, while the lotic habitats were found as relatively more contaminated components. According to the results of Heavy Metal Pollution Index (HPI) and Heavy Metal Evaluation Index (HEI), it was also determined that arsenic was found as the relatively most critical toxicant among the investigated toxic elements. It was also determined that Çokal Dam Lake Basin found as "Low heavy metal contamination" and "Suitable for consumption" in terms of applied HPI and "Low contamination" and "Suitable for use" in terms of applied HEI.

In line with the data of the current investigation, in order to maintain the sustainability of this significant dam lake basin, which is of great importance especially for the people living in the region, it is recommended to continuously monitoring the accumulation levels of toxic metal in water, sediment and biotic factors.

Acknowledgements
The authors would like to thank to Trakya University Scientific Research Projects Unit for the financial support to this research.

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COMPETITIVE ANALYSIS OF UNMANNED AERIAL SYSTEMS IN AEROPHOTOGRAMMETRY

DOI: https://doi.org/10.18509/GBP23263v
UDC: 528.837.042:629.73

Vladimir Vučenov[1]
Marko Stojanović[1,2]
Jasmina M. Jovanović[3]
Mihajlo Bobar[1]
Marko Simić[1]
[1]Military Geographical Institute - "General Stevan Bošković", Belgrade, **Serbia**
[2]Military Academy, University of Defence, Belgrade, **Serbia**
[3]Faculty of Geography, University in Belgrade, **Serbia**

ABSTRACT

In the past decade we have witnessed the accelerated development of unmanned aerial systems and photogrammetry sensors. For that reason, its role in modern aerophotogrammetry is becoming even more significant. Today, there is a large number of easily available unmanned aerophotogrammetric systems with sensors of satisfactory quality, and lower cost of acquisition and use, in comparison to standard manned aerophotogrammetric systems.
This paper contains a competitiveness analysis conducted in order to compare the application of unmanned aerial systems in aerophotogrammetric survey and classic manned aerial systems which still have a dominant role and represent a standard in this field.
By comparative analysis of those two systems, their similarities and differences, advantages and disadvantages, all based on specific examples, their characteristics and technical capabilities, applied technologies and procedures, prices and end result, a conclusion was drawn in order to answer the question whether unmanned aerial systems can take primacy in aerophotogrammetry.

Keywords: Aerophotogrammetry, Unmanned aerial systems, Manned aerial systems, Photogrammetric sensors

INTRODUCTION

Manned systems have been the backbone of aerial photogrammetry for over 70 years. Due to the extremely high costs of acquisition and operation, aerial photogrammetry surveys were mainly carried out by the government, much less often by the private sector. With the development of unmanned systems, aerial photogrammetric survey has become available to a much wider range of users. New unmanned aircrafts, new sensors of smaller sizes, with ever-increasing possibilities of application, rapidly began to emerge.
The time has come to ask the question of what the future holds for aerial photogrammetry: is the technology of unmanned aerial photogrammetry systems sufficiently advanced and ready to take over from manned aerial photogrammetry systems?
A comparative analysis, by means of description of both technologies, will answer the question of where aerial photogrammetry is today, and more importantly, where will it be in the near future.

There are many combinations of manned aircrafts and photogrammetry sensors in use today, as well as a large number of unmanned aerial photogrammetry systems. The two specific aerial photogrammetric systems, manned and unmanned, which are analysed and compared in this paper, were chosen based on the author's career experience.

AEROPHOTOGRAMMETRY

Photogrammetry is the science of obtaining reliable information about properties of physical objects and surfaces without direct contact with the object of measurement and of interpreting of the obtained data. Its methods of geodetic survey of large areas are incomparably efficient. Information about measured objects is obtained by use of sensors that register electromagnetic radiation, most often in the form of a photographic image, but other types of sensors, such as lasers, can be used as well.

Aerophotogrammetry is a branch of photogrammetry with the sensor located in the aircraft and the survey is performed from the air. It deals with survey at distances (altitude) of several thousand meters with an accuracy of tens of centimetres. It is used in geodesy to create orthophotos, digital terrain models, topographic maps, etc [1]..

MANNED AEROPHOTOGRAMMETRY SYSTEMS

A manned aerial photogrammetry system consists of a specially modified aircraft that has a factory or retrofitted opening in the floor, an aerial photogrammetry sensor with a special stand that is placed above the opening in the floor of the aircraft, and a control station that connects the aircraft and the sensor, through which the survey process is managed, and the pilot is instructed.

Aerial photogrammetry cameras have the same basic features as standard cameras, but are much larger, heavier, automated, and specially designed for use in aircrafts. Cameras are used at heights of several kilometres in a very challenging environment that involves sudden changes in temperature and strong vibrations during operation. Despite this, high quality survey results are required from these cameras. Due to the large distance from the recording object, the lenses are much larger than those of regular cameras. The shutter speed needs to be significantly faster and the exposure much shorter. Cameras must have special stands that neutralize vibrations and compensate for the aircraft's flight speed during survey. All this results in a very high price. Due to the high purchase price, but also high reliability in exploitation, these cameras have a service life that is measured in decades.

DESCRIPTION OF MANNED SYSTEM PIPER SENECA V EQUIPPED WITH LEICA ADS80

The Piper Seneca V aircraft (Figure 1) is a twin-engine aircraft equipped with turbocharged piston engines, all-metal construction and retractable landing gear [4]. The aircraft is intended for aerial photogrammetric survey of the terrain.

Figure 1. Piper Seneca V, YU-VGI [2].

It is equipped with an aerial photogrammetric camera Leica ADS80 (Figure 2) that works as a scanner – recording is continuous. This means that one flightline is one photo. This technology (pushbroom) enables much simpler processing of the survey results. There is a pilot and a sensor operator in the aircraft. The operator manages the surveying process and controls the operation of the camera through the control station. The pilot controls the aircraft according to the flight plan and makes corrections during the flight in accordance with the given flightlines.

Figure 2: Leica ADS80 camera [3].

A description of the manned aerial photogrammetry system used in the Military Geographical Institute - "General Stevan Bošković", Belgrade provides in Table 1.

Table 1: Piper Seneca V specification [4].

Aircraft type:	Airplane
Aircraft weight:	1.457 kg
Wingspan:	11,9 m
Propulsion:	2 turboprop engines with a power of 220 hp each
Fuel consumption:	79 l/h
Range:	1.534 km
Air speed:	Up to 370 km/h
Maximum flight height:	7.000 m above the ground
Takeoff:	Hard surface runway
Landing:	Hard surface runway
Equipment:	- Leica ADS80 - GNSS Receiver

UNMANNED AERIAL SYSTEMS

Unmanned Aerial System consists of unmanned aircraft, a control station on the ground and a data link between the control station and the aircraft.

The generally accepted term for an airplane that does not have a pilot in the aircraft is UAV (Unmanned Aerial Vehicle). The basic division of unmanned aircraft is based on whether they are lighter or heavier than air and whether they are self-propelled or wind-powered. Unmanned aircrafts heavier than air are divided into aircrafts with flexible (soft) wings, hard wings, and rotary wings. They can also be self-propelled or wind-powered.

Historically, lighter-than-air and wind-powered flexible-wing UAVs were once dominant, but today they have been supplanted and are much less commonly used commercially.

Self-propelled fixed-wing unmanned aircrafts may have propellers driven by an electric or internal combustion engine, or may be jet-powered. These aircrafts have wings shaped in such manner to generate lift when the aircraft is moving forward at sufficient speed.

Unmanned rotary-wing aircrafts are principally self-propelled. They are called copters. They have the ability to take off and land vertically, as well as to hover in place. Copters can have one, two, four or more rotors driven by a drive shaft.

According to take-off weight, unmanned aircrafts can be micro (up to 100 grams), small (up to 150 kilograms) and large (over 150 kilograms).

Control station on the ground - GCS (Ground Control Station) is the brain of the system. It is used for operating and control of the unmanned aircraft, directly or by means of predetermined flight plan.

Link for data exchange - Data Link is used for establishing communication between the control station and the unmanned aircraft. This connection is used to control the aircraft in flight. It is possible to upload a flight plan to the aircraft before the flight, send the telemetry data of the aircraft to the control station during the flight, as well as send the recording results in real time during the flight or after the flight has been finished. Communication is realized via radio link.

UNMANNED AERIAL PHOTOGRAMMETRY SYSTEMS

An unmanned aerial photogrammetric system is a remotely controlled, semi-automatic or automatic aerial platform equipped with a photogrammetric sensor (camera, multispectral

camera, thermal camera, lidar, or a combination of two or more sensors). The difference between an unmanned aerial system and an unmanned aerial photogrammetry system is the sensor carried by the unmanned aircraft.
Effective application of unmanned aerial photogrammetry systems in photogrammetry depends on achieving the ideal compliance of the unmanned aircraft as a platform and the sensors it carries. Higher quality photogrammetric sensors weigh more than amateur sensors and require larger and stronger, and therefore more expensive, unmanned aerial vehicles to carry them. Today there are unmanned aircraft with a payload of over 100 kilograms and large enough to carry a professional aerial photogrammetry camera used in manned aircraft, but the cost of acquiring and using such an unmanned aircraft is similar or even exceeds the cost of using a classic aerial photogrammetry manned platform. In order for unmanned aerial photogrammetry systems to be competitive with manned aerial photogrammetry systems, they must have the same or better quality of survey results at much lower costs. For this purpose, it is necessary to find the optimal ratio between the capabilities and the price of the unmanned aerial vehicle and the photogrammetric sensor.
The growing and faster development of unmanned aerial vehicles has encouraged the development of ever smaller and lighter photogrammetric sensors while maintaining the quality of imaging. Thus, Sony developed the DSC-RX1 digital camera (Figure 3), the world's smallest camera with a full-size sensor. This camera weighs only 500 grams. When it comes to thermal cameras, the company "Flir" achieves excellent results in reducing the weight and dimensions of digital thermal cameras.

Figure 3: Sony RX1 camera [5].

A considerable challenge for unmanned aerial photogrammetry systems are Lidar (Light Identification Detection And Ranging) sensors or, in other words, laser scanners. Even though sensors of reduced mass and dimensions are developed in order to enable unmanned aircrafts to carry them, nevertheless, the quality-price ratio of the obtained results is not yet competitive with the existing sensors on manned aircraft.

DESCRIPTION OF THE GEOSCAN 201 UNMANNED SYSTEM

The Geoscan 201 system consists of an aircraft, a control station, a radio link between the control station and the aircraft, and a launch pad for the aircraft to take off. The control station (laptop computer) contains the control software. The flight is performed automatically. The operator at the control station is there only to monitor the aircraft's telemetry and recording characteristics. In case of unforeseen circumstances, the operator can take manual control of the aircraft at any time. It receives real-time data on the flight and on every shot taken. A description of the unmanned aerial photogrammetry system Geoscan 201 provides in Table 2.

Table 2: Geoscan 201 specification [6].

Aircraft type:	Flying wing
Aircraft weight:	8,5 kg
Wingspan:	222 cm
Propulsion:	Electric motor
Flight duration:	Up to 180 minutes
Airspeed:	64 – 130 km/h
Maximum flight altitude:	4.000 m above the ground
Minimum flight altitude:	100 m above the ground
Takeoff:	Launch pad
Landing:	Parachute
Equipment:	- Sony DSC RX1R camera - GNSS receiver
Communication:	Radio link
Maximum wind strength:	10 m/s measured on the ground
Temperature range:	Between -20 °C and +40°C

The aircraft used in the company "Evrogeomatika" d.o.o. based in Belgrade (Figure 4) allows the use of one to three sensors. A SONY RX1 camera is installed as standard. Photo resolution is 24,7 MP. It features a Carl Zeiss lens and a full-size (35 mm x 26 mm) sensor.

Figure 4: Geoscan 201 [7].

Depending on the needs, a video camera, a multispectral camera, an infrared camera, or some other sensor can be installed in the remaining sensor slots. The sensors are connected to the autopilot on the aircraft, which regulates their operation depending on the present recording parameters. All sensors are powered by the aircraft battery.

In the right wing of the aircraft there is a Topcon dual-frequency GNSS receiver with a speed of registering signals from satellites up to 10 Hz. This receiver is what provides the geodetic component to this system, and it makes it possible to obtain data with centimetre horizontal and height accuracy. After fieldwork is completed, after one or more flights, the autopilot and camera data from each flight are processed in photogrammetric processing software.

COMPARATIVE ANALYSIS OF MANNED AND UNMANNED AEROPHOTOGRAMMETRIC SYSTEMS

The specific characteristics of two aerial photogrammetry systems, manned and unmanned, on the basis of which the possibilities and competitiveness of these systems can be analysed presents in Table 3.

Table 3: Comparative systems analysis

	Piper Seneca V **Leica ADS80**	**Geoscan 201** **Sony RX1**
System price	≈ 1.000.000 € - aircraft ≈ 1.000.000 € - sensor	≈ 50.000 €
Crew	Pilot Operator	Operator (on the ground)
Flight cost	≈ 1.500 €/h	≈ 0.1 €/h
Surveying resolution 3 cm		
Area size	-	≈ 15 km^2
Surveying resolution 10 cm		
Area size	≈ 600 km^2	≈ 42 km^2
Surveying resolution 40 cm		
Area size	≈ 2.400 km^2	-

The first thing that comes to attention is the cost of the manned aerial photogrammetry system. Having in mind the cost of the aircraft and of sensors, it is clear that this system requires a large initial investment. On the other hand, an unmanned aerial photometric system is 40 times cheaper and therefore available to a much wider group of users.

Another component which affects the cost of using the system is the training and wages for those engaged in surveying. A qualified professional pilot who is required to operate an aircraft must undergo very demanding and expensive training. The pilot and aerial photogrammetry operator work in a dangerous and unnatural environment, which affects their salary. An airplane burns large amounts of fuel during flight. In contrast, the unmanned aircraft operator training is far simpler and cheaper, the workplace is much safer, and the salary costs are much lower. The electric motor that drives the unmanned aircraft is powered by a battery that is charged from the power grid before flight, so flight costs are negligible.

In terms of applicability, the situation is also very different. Unmanned aerial photogrammetry systems can fly at much lower altitudes than manned systems. The advantage is a higher image resolution, but the downside is a much smaller survey area that can be covered in one flight. The maximum flight height of the Geoscan 201 system of 4.000 meters above the ground is impractical for the purposes of aerial photogrammetry. Namely, the Sony RX1 sensor is not capable of taking high-quality shots at that height due to its technical characteristics (primarily focal length). The distortion of the footage is too great. Sensors on manned aerial photogrammetry systems are designed to work at high altitudes and enable large surveying areas in one flight.

We can directly compare the potential of the two systems by analysing the only comparable example in the table - the surveying resolution of 10 cm. The manned system can cover an area 14 times larger during one aerial photogrammetric survey. This difference is still 3 times smaller than the difference in the purchase price of the system.

This means that using several unmanned aerial photogrammetry systems can further neutralize the advantage of the manned system.

CASE STUDY

In order to obtain valid study results, a case study is introduced, and its data analyzed. An area of 25 square kilometers between the city of Ruma and the village of Voganj was used for purpose of providing a case study (Figure 5). This area was chosen since one year apart aerial photogrammetric survey was carried out both with an aerial photogrammetric system Piper Seneca V and with an unmanned aerial photogrammetric system Geoscan 201. For the purposes of the land consolidation project in the cadastral municipality of Voganj, the company "Evrogeomatika" d.o.o. performed an aerial photogrammetric survey of this area on April 10, 2018. On April 16, 2019, the Military Geographical Institute - "General Stevan Bošković" carried out an aerial photogrammetric survey of the same area as part of the IPA 2014 project "Special measures for reconstruction after floods and flood risk management - Serbia". A comparative analysis of the surveying results is given in Table 4.

Figure 5: Case study area [8].

Table 4: Comparative analysis of the surveying results

Area size ≈ 25km^2	**Piper Seneca V** **Leica ADS80**	**Geoscan 201** **Sony RX1**
Date	16.04.2019.	10.04.2018.
Flights	1	2
Flight altitute	2.000 m	400 m
Surveying time	≈ 20 min	≈ 160 min (100+60)
Surveying resolution	20 cm	4 cm
Images obtained	8	3.940 (2.466+1.474)
Single image size	≈ 4,5 GB	≈ 11 MB
Total images size	38 GB	41 GB

Based on the technical characteristics of the manned aerial photogrammetry system Piper Seneca V, it is clear that one flight is more than enough for surveying this area. The plane took off from Belgrade, arrived at the assigned area, performed aerial photogrammetric survey of 8 flightlines according to the predetermined flight plan, after which the plane returned to Belgrade. Since the aircraft departed from Belgrade, it had enough time to reach the required flight altitude before arriving at the surveying location. On the other hand, the unmanned aerial photogrammetry system Geoscan 201 was transported by road vehicle from Belgrade to the given location. Based on the surface area and the defined flight altitude, for safety reasons, it was decided to perform two surveying flights. After the first flight, the recording data was downloaded, the battery was replaced, and the second flight was carried out. At the beginning of both flights, the aircraft had to spiral up to the set flight altitude first, and only then start recording, which consumes a lot of time and aircraft's battery.

The Leica ADS80 sensor on the manned aerial photogrammetry system is equipped with a push broom imaging technology, which means that each flightline is a single shot. Therefore, the number of obtained images is 8. The Sony RX1 sensor of the unmanned aerial photogrammetry system makes individual images. It is noticable that the total size of data obtained with both surveying methods is similar. During the processing of the data obtained from the manned aerial photogrammetry system, it should be kept in mind that it is a small number of a large size images. This increases the processing time and requires higher hardware capabilities of the processing computer. The data of the unmanned aerial photogrammetry system is characterized by a very large number of small-sized images, which speeds up the processing time and reduces hardware requirements. Data can be divided into smaller blocks and thus processed.

The same detail is displayed on Figure 6, captured by manned and unmanned aerial photogrammetry systems. Based on this example, it is clear that the image quality surveyed by the unmanned aerial photogrammetry system is much better at smaller scale. This is a great advantage in the further application of the surveying results, especially in urban areas or areas of special interest. But on the other hand, as seen in Figure 5, a large percentage of the surveyed area consists of fields and uninhabited areas. This is the case in most aerial photogrammetry surveys. The technical capabilities of unmanned aerial photogrammetry systems exceed the requirements related to the quality of data recorded in these areas, while the time and resources required to image these areas with unmanned aerial photogrammetry systems are impractically extensive.

Figure 6: Church in vilafe of Voganj. left image taken with Leica ADS 80 sensor [8]; right image taken with Sony RX1 sensor [9];

ADVANTAGES AND LIMITATIONS OF THE APPLICATION OF UNMANNED AERIAL SYSTEMS IN PHOTOGRAMMETRY

The main advantage of unmanned aerial systems compared to manned aircraft is the possibility of use in dangerous situations, such as natural disasters (volcanoes, floods, etc.), riots and war environment, without risking the lives of the operators. Due to their construction and size, they can be used in inaccessible areas. Due to the low flight height, they can be used under clouds or under the restricted flight zone.

Modern unmanned aerial photogrammetry systems have the ability to process data in real time. The size of the images is much smaller compared to professional aerial photogrammetry cameras, so it is possible to transfer data during the flight from the aircraft to the control station via radio link.

Copters have the possibility of vertical take-off and landing and hovering in place, which has a great application in engineering photogrammetry in the creation of detailed and precise 3D models. In close-up photogrammetry, it is possible to combine aerial photography with terrestrial photogrammetry using identical sensors to obtain images of the same quality, which facilitates further processing.

The basic limitation of unmanned aerial photogrammetry systems is the payload, which is determined by the mass, dimensions, and engine power of the unmanned aircraft. This is why amateur digital cameras or sensors are generally used in these systems, being much lighter than professional sensors. This affects the surveying quality, especially at higher flight altitudes. What’s more, a much larger number of images are needed to cover the same area compared to classic aerial photogrammetry systems.

Insufficiently defined legal regulations in many countries cannot be ignored, since it is a considerable limitation of unmanned aerial systems. It is generally not required for unmanned aircrafts to use automatic identification devices or automatic mid-air collision avoidance devices as is the case with manned aircrafts. In order for efficiency to stand out, the optimal flight height of an unmanned aerial photogrammetry aircraft is several hundred meters. Those heights are mainly intended for flights of manned aircrafts, which can make the use of unmanned aircrafts very dangerous depending on the legal regulations, i.e., its deficiencies.

Flight autonomy is much lower when it comes to unmanned aircrafts compared to manned aircrafts. It depends on the unmanned aircraft drive type. Unmanned aircrafts can have an electric motor, in which case a larger battery capacity increases the weight of the battery,

consequently the weight of the aircraft itself, reduces the payload, i.e., reduces the flight autonomy. Unmanned aircrafts powered by internal combustion engines need to overcome the heaviness of the engine itself, along with the weight of the fuel, which again increases the total weight, reduces the payload, that is, reduces the flight autonomy.
The maximum range of an unmanned aircraft represents another limitation. The range of an unmanned aircraft may be greater than the range of the radio link with the control station. In this case, the flight of the unmanned aircraft can be continued without radio communication with the control station in automatic mode, which represents a great risk, or the range of the unmanned aircraft must be reduced in order to be within the range of the radio communication.

CONCLUSION

Ten years ago, it was unthinkable to question the competitiveness of unmanned aerial photogrammetry systems with manned systems. The best-case scenario was to use unmanned systems as a supplement to classic aerial photogrammetry, that is, as a substitute for supplementary terrestrial measurements by classic geodetic methods.
The situation is completely different now. Advances in technology have increased the capabilities, reliability and affordability of unmanned aerial systems, while the costs of acquisition and use have been reduced. Today, unmanned aerial photogrammetry systems are much more competitive with classic manned systems. They succeed in fulfilling their mission, to achieve the same or higher quality recording results with lower costs.
Where unmanned systems still lag behind manned systems is the ability to survey large areas. There is often no need for high image resolutions, especially in unpopulated areas, which make up most of any countryside. Here, the higher surveying resolution is not an advantage, but a limitation. When surveying monotonous surfaces, for example forests, a large number of images with practically the same content make photogrammetric processing difficult.
Based on all arguments listed in this paper, we may conclude that nowadays the best results can be achieved by using both systems, having the advantages of each contribute to the overall result. By combining manned and unmanned aerial photogrammetry systems, a greater coverage of imaging is obtained where it is needed (unpopulated areas) as well as a higher resolution of imaging (inhabited areas, rail and road infrastructure). This approach greatly facilitates further processing and gives much greater possibilities for the application of final products.
In order for unmanned aerial photogrammetry systems to become competitive with manned systems, they still have to come close to their technical capabilities. The most significant limitation is the available battery technology for electrical energy storage. The ratio of battery weight to the amount of electricity it can store is still not optimal. The next revolution in electricity storage technology is required. Photogrammetric sensors must continue the trend of reducing dimensions and weight while maintaining or improving their characteristics. Unmanned systems technology is rapidly approaching manned systems and will undoubtedly become the new standard in aerial photogrammetry in the near future.

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POSSIBILITIES OF SMART DEVELOPMENT OF RURAL AREAS – CASE STUDY OF THE GRÓJEC COUNTY IN POLAND

DOI: https://doi.org/10.18509/GBP23275b
UDC: 528.44:911.373-043.86(438)

Anna Bielska
Wioleta Galbarczyk
Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadastre and Land Management, Warsaw, **Poland**

ABSTRACT

The study objective was to determine the development opportunities for the functions that currently exist in the Grójec County, and to identify areas with the possibility of implementing new functions as part of multifunctional development with the application of smart technologies. It was assumed that using smart technologies according to the Smart Villages concept would increase the productivity of the areas, minimise costs, and enhance the protection of the natural environment, including soils.

The study also seeks to describe a new concept proposed by the European Union, namely the idea of Smart Villages. It is based on the local strengths of a given area, and has a significant impact on the development of rural areas as well as on the improvement of the quality of life and working conditions. The paper discusses new trends in rural development. It provides examples from Poland and other countries regarding possible strategies of implementation of innovation and modern technologies in farming for the improvement of the standard of public services and local resource utilisation

The study presents the characteristics of the Grójec County. The SWOT analysis was developed based on the identified factors, presenting the development opportunities for the region. It permitted the determination of opportunities for growth, and provided the basis for defining strategic development goals and actions. The study presents the development opportunities for the county in the context of its close proximity to large agglomerations, allowing for the growth of the economic and tourist zones and an increase in the income to the national budget, resulting in both infrastructural and social regional development. The study identifies areas requiring strengthening of the local resources and their management, those with the possibility of developing the existing functions, and those with the possibility of introducing new ones.

Financial solutions from various sources, e.g. European, national, and communal, are suggested. The paper also offers recommendations for updating the study of conditions and directions of spatial planning, considering all of the conditions that may affect the use of given land.

Keywords: Smart Villages, rural area, rural development.

INTRODUCTION

The Smart Villages concept is based on the use of innovative tools and digital technologies for the improvement of the quality of life and elevating the standard of public services for rural communities [1]. The Smart Villages concept is a response to the search for methods of implementation of sustainable development in the context of intensifying problems and challenges in rural development, particularly in peripheral areas [2]. It is not a universal concept. Its implementation requires an individual approach with consideration of the local conditions [3]. No guidelines exist regarding the type of analyses required for the choice of solutions most suitable for a given area [4]. Promotion of Smart Villages and offering support is an important element of budgeting European funds for the upcoming years.

The implementation of the Smart Villages concept aims at among others facilitation of transfer of knowledge and innovation in rural areas. The European Network for Rural Development (ENRD) designated areas of smart measures in three main areas of smart solutions [5]:

- public services, including: energy production (RES), safety (video monitoring), remote education, raising awareness among residents, public transport, e-health
- management, including: public e-administration, waste management (fill-level sensors in containers), spatial planning, quality monitoring
- environment (air quality sensors), meetings and online consultations with residents
- entrepreneurship, including: precise agriculture, e-commerce (sale of local produce), rural tourism (based on smart solutions), sharing equipment (specialist equipment), rural incubators.

There are many interesting examples of innovative solutions applied in the scope of the Smart Villages concept in various areas of activity, including: local development, farm’s performance, restructuring and modernisation, biodiversity restoration, preservation and enhancement, agri-food chain integration and quality, innovation and cooperation, diversification and job creation, links with research and innovation. According to data of the European Network for Rural Development (ENRD), approximately 900 projects implemented to date involved the participation of 28 European countries. In the scope of these funds, Poland implemented 41 projects [6]. Moreover, Poland has been implementing Smart Village projects in the scope of national funds since 2017 [7].

The study objective was to determine the possibilities of development of the existing functions occurring in the study area, and identification of areas with a potential for introduction of new functions in the scope of multifunctional development with the application of smart technologies. It was assumed that the use of smart technologies pursuant to the Smart Villages concept would contribute to an increase in the productivity of the areas, minimisation of costs, and strengthening of the possibilities of protection of the natural environment.

MATERIALS AND METHODS

Study area

The study was conducted in the Grójec County in the central part of Poland, in the Mazovia Voivodeship (Fig. 1). It covers an area of approximately 1,268 km^2. Its population is 98,173, accounting for population density at a level of 78 persons/km^2. The urbanisation rate is 35.3%. (GUS 2020). The location of the Grójec County approximately 50 km south of Warsaw, the capital city of Poland, offers enormous opportunities in the scope of infrastructure and social development of the area. The Grójec County borders on the Vistula River (largest river in Poland) to the east, and the Pilica River attractive in tourist terms to the south. The Grójec County covers 10 communes (Fig. 2). The most important ecosystems for the Grójec County include forests and forest land. The total surface area of forest land in the Grójec County reaches approximately 13% of the study area. Around 66 nature monuments are subject to protection. Natura 2000 network areas occupy approximately 10% of the territory of the Grójec County (Development Strategy of the Grójec County) [8].

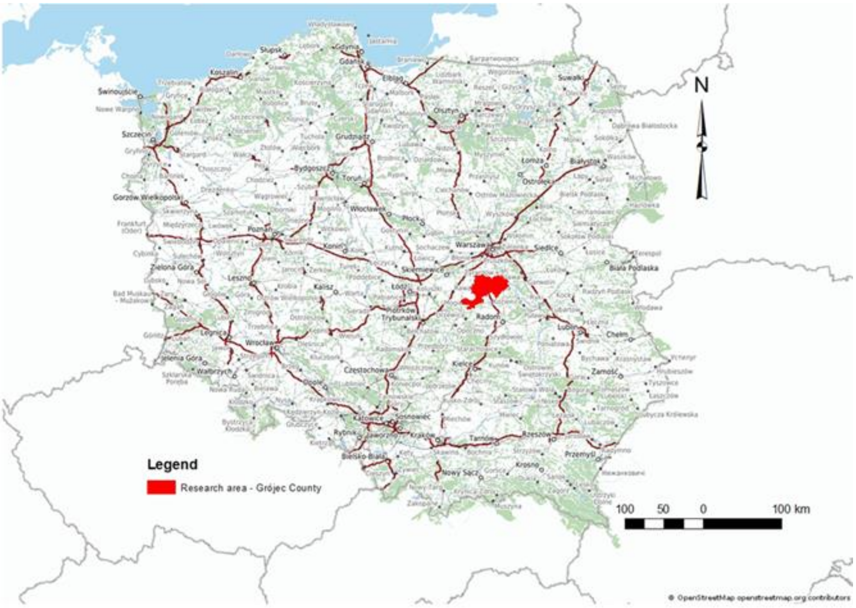

Figure 1. Location of the research area - the Grójec County
Source: Own study based on the OpenStreetMap

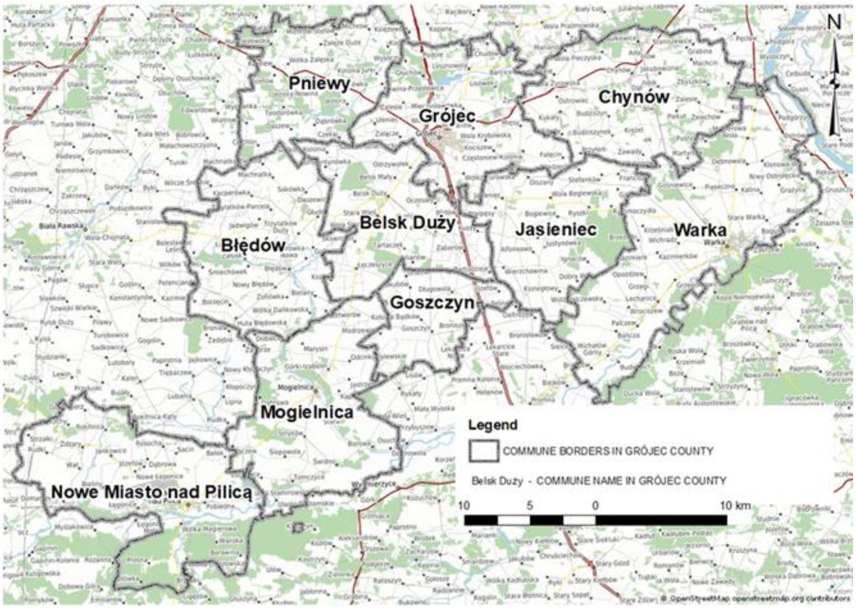

Figure 2. Location of the research area, division into 10 communes
Source: Own study based on the OpenStreetMap

The primary area of economy in the county is agriculture, whereas the main direction of production is horticulture. Orchards occupy approximately 33% of the arable land in the county. The Grójec County, called "the largest orchard of Europe", boasts more than 500 years of horticulture traditions dating back to the times of Queen Bona who received vast amounts of land in this part of the country in the 16th century, and established a royal fruit tree plantation dominated by apple trees. The average production of apples here is at a level of 700-800 thousand tonnes, accounting for approximately 45% of the national production. The horticulture tradition in the Grójec County determines the directions of development of the region, and is the primary place of employment for county residents. Apple production is provided by around 7,500 farms with an average surface area of 7.0 ha (including orchard area of 4.2 ha).

The remaining sectors of the economy of the Grójec County include:

- wholesale and retail sale, repair of car vehicles (36%),
- construction (11%),
- transport and warehousing (9%).

The Grójec County is largely dominated by individual farms, constituting more than 99% of all agricultural farms. In the period 2010-2020, the number of the large farms belonging to groups of arable fields with an area of more than 15 ha increased. The size structure of agricultural farms in 2020 was dominated by small farms with an area of up to 5 ha [9].

Study methods and materials

The study employed the method of analysis of scientific literature regarding rural development and the Smart Villages concept. It was also based on information published on websites of relevant governmental units. The SWOT analysis for the Grójec County was developed based on own research and observations. The spatial scope covers the area of the Grójec County, Mazovia Voivodeship in Poland.

The following data sources were used:

- Strategy for the development of the Grójec County 2018-2023,
- Strategy for the development of the Mazovia Voivodeship 2030+ innovative Mazovia,
- Spatial development plan for the Mazovia Voivodeship
- Strategy for the Development of all (10) communes in the Grójec County
- Studies of conditions and directions of spatial planning of all (10) communes in the Grójec County
- the National Register of Boundaries (NRB), covering the borders of communes in the Mazovia Voivodeship
- OpenStreetMap and Topographic Objects Database, for the communication network and land cover
- the Central Statistical Office (Statistics Poland), characterising the population and economic situation of the communes.

The study used the basic and advanced functionalities of Esri's ArcGIS Desktop software package, allowing for the collection, analysis, and processing of spatial data.

RESULTS AND DISCUSSION

Determination of the possibilities of rural development in the study area

The Grójec County primarily fulfils agricultural and industrial-service functions, with a small share of the tourist function. A survey conducted in 2014 [10] showed that most farms of the Grójec County featured specialist objects for storing fruit. Approximately 75% of them also had specialist cold storages for storing fruit, and 13% had storerooms. Processes related to the restructuring of agriculture will provide conditions for increasing the number of business entities related to agricultural services and agricultural-food processing [11]. Strengthening of the role of producers and producer groups in the market of agricultural products, as well as "ecologisation" of agriculture will also generate new jobs [12]. Owing to the global trend of growing ecological social sensitivity, demand for high quality healthy food products is on the rise. Organic food is increasingly valued, primarily in large cities, where residents are eager to pay for it more (…). High dynamics of export of products from the Grójec County point to their competitiveness in the European and global market. The county requires strengthening of information and consultancy support for organic farmers, particularly in the scope of information, marketing, and popularisation of innovative technologies. Strengthening of the position of farmers in the Grójec County in the food supply chain and promoting short supply chains deserves particular attention with regard to such activities. The primary objective of such activities is reducing the route of products from farm to table, and support of local producers and farmers. Owing to its specific and unique properties, food produced and sold locally is a flagship of the heritage of the region it comes from, but its importance has an even deeper meaning. The primary direction of activities will be the elimination of weaknesses of the county, and particularly:

- activisation of farmers of the Grójec County;
- promotion of openness towards control and certification proceedings guaranteeing higher product quality;
- creating the appropriate image of individual farms active in the retail market;
- creating sales networks with a coherent image;
- cooperation of producers for shared promotion and distribution for the purpose of increasing their competitive advantage;
- increasing commercial resources and product improvement;
- management of the quality and flow of information from farmers and producer groups to consumers with consideration of feedback;
- support of retail sale of food in local and regional sales strategies.

An increase in efficiency will be obtained by means of the application of smart systems of precise agriculture. Digital technologies can support farmers in the Grójec County in obtaining greater efficiency while reducing costs. It offers a solution to the current and future challenges in the scope of climate change, responsible use of limited natural resources, and food safety. The existing and new technologies will contribute to greater effectiveness of processes and permit development of new products and services.

The development of the holiday and recreation function can be based on the local resources of the natural environment. This particularly concerns the presence in the county of areas predisposed for the introduction of recreation facility development, implemented in response to the demand of residents of the Warsaw metropolis. The use of these resources may be related to legal allocation of land of investment. The developed local plans of spatial development stipulate and enable the implementation of such services. The primary direction of development is combining the functions of agricultural production in selected areas with the development of services related to agriculture, small entrepreneurship, and recreation and agritourism while improving the state of both technical and social infrastructure.

The county features a low level of use of renewable energy sources (RES) in housing, public purpose buildings, and enterprises. The determined primary direction of development of the RES sector in the study area was energy production based on the use of wind and co-incineration of biomass in large systemic power plants and heat power plants. The Grójec County is located in the central region with mean total annual solar radiation of 1000-1050 kWh/m2. Mean total insolation in a year is in a range of 1900-2000 h/year. Therefore, the county provides good conditions for the development of solar energy production. The preferred direction of development of solar energy production in the county should be mounting individual small photovoltaic installations on residential and public purpose buildings [8], [9].

SWOT analysis

The SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is one of the most popular analytical techniques for classifying information. It is applied in all areas of strategic planning as a universal tool at the first stage of strategic analysis. The SWOT analysis provides a valuable analytical result, and is an effective method of identification of categories of weaknesses and strengths as well as opportunities and threats. It allows for using collected information for the development of e.g.: development strategy based on strengths and opportunities, with simultaneous elimination or limitation of weaknesses and threats, marketing strategy, and positive brand image.

Factors in the SWOT analysis were classified in the paper as follows:

- STRENGTHS: internal factors with a positive effect on the development of the Grójec County that make it positively stand out in the surroundings, providing the basis for its future development, increasing its attractiveness and competitiveness in the perception of residents, investors, tourists;
- WEAKNESSES: internal factors with a negative effect on the development of the county that inhibit the development and implementation of plans; gaps in potentials that reduce the position of the county both in the perception of the resident and external entities;
- OPPORTUNITIES: external factors favouring the development of the Grójec County and obtaining the designated objectives, allowing for elimination of weaknesses, increasing strengths, and initiating new directions of development;
- THREATS: external factors inhibiting the development of the county and obtaining the designated objectives, constituting barriers in overcoming the current difficulties, and blocking the possibilities of undertaking activities in various areas important from the point of view of the development of the county.

Table 1 presents the SWOT analysis for the Grójec County. The analysis concerns the current situation of the county.

Table 1. SWOT analysis for the Grójec County

STRENGTHS	WEAKNESSES
• Favourable location of the county and good transport connections • Highest level of development of horticulture production and the related services in Poland • High level of development of the tourist structure (water courses, cycling paths, walking paths, etc.) • Considerable cultural heritage resources • Good conditions for the development of agritourist farms	• Low level of development of the accommodation offer • Aging society • Low level of use of the tourist and cultural potential • Insufficient support for local business • Lack of local spatial development plans, progressing uncontrolled urbanisation and defragmentation of cultural landscape
OPPORTUNITIES	THREATS
• Introduction of innovativeness in the scope of horticulture and processing • Development of export of fruit and food products • Development of agritourism • Efficient use of the cultural heritage, promotion of regional products and brands • Development of service and commercial activity	• Migration of persons at productive age to cities due to the lack of attractive job offers • Neglect of the cultural heritage due to the lack of resources and preventive procedures • Low activisation in the context of creating new non-agricultural jobs • Pollution and degradation of the natural environment

Recommendations for updating planning studies in the study area

The study allowed for formulating recommendations for updating studies of conditions and directions of spatial planning of communes of the Grójec County in the scope of possibilities of development of functions existing in the county, and indication of areas with a possibility of introduction of new functions in the scope of multifunctional development with the application of smart technologies.

Obtaining harmonious, comprehensive, and sustainable development of the Grójec County providing for economic stability, spatial order, preservation of the environmental and landscape values, complete provision of equipment and infrastructure, proper service in the scope of transport, meeting current needs of residents, providing conditions for a constant increase in the level of quality of life, and meeting the needs of future generations requires the following:

- provision of relevant possibilities of development of the city as a regional centre of administration, housing, services, etc.;
- strengthening of the leading role of horticulture and the related infrastructure, warehousing, processing, etc.;
- use of the opportunity of creating an economic zone within the county,
- development of a network of objects of transport services on the existing routes of national and regional roads;
- development of the functional-spatial structure adjusted to the ecological systems;
- development of functions in line with the existing environmental conditions;
- protection of special environmental and cultural values, as well as values for the development of recreation, holiday stays, and tourism;
- treatment of environmental protection as an integral part of all development processes;
- conducting rational management of resources, particularly waters, forests, agricultural production space, etc.

natural or cultural resources justify the determination and indication of activities in the communes of the Grójec County providing the basis for updating the study of conditions and directions of spatial development. Smart development of strategic objectives of rural development and activities stipulated for implementation will increase the settlement, investment, and tourism and recreation competitiveness of each commune of the Grójec County.

Table 2 and Table 3 presents the proposed directions of development and priority measures for particular communes of the Grójec County (Fig. 2), with consideration of the natural resources of the county that constitute a valuable element contributing to the development of the region.

Table 2. Proposed directions of development and priority measures for the urban–rural communes of the Grójec County

Name of commune of the Grójec County	Directions of development of the commune	Priority measures supported by intelligent solutions
Urban–rural Commune Grójec	• Creating a fruit and vegetable logistic centre • Development of agricultural-food industry based on own resources • Offering the highest quality agricultural production	• The use of the "Grójec apple" for the purposes of promotion of the region in Poland and abroad • Initiating and strengthening economic bonds with Polish and foreign partners • Emphasising agricultural products and services in the business offer of the commune
Urban-rural Commune Warka	• Development of agricultural-food industry • Development of modern production methods in local agriculture	• Increase in accessibility through creating a market information system for local agriculture • Introduction of modern techniques and machines • Creating specialist companies providing services to local farmers
Rural-urban Commune Nowe Miasto nad Pilicą	• Development of tourist-recreation functions through the use of the environmental-landscape and historical-cultural values • Modern and open tourist economy • Development of tourist and related infrastructure for the development of tourism • Improvement of the innovativeness, attractiveness, and quality of tourist products and services	• Promotion of priority areas of the commune (e.g.: year-round strategy of promotion in social media, Facebook page, Instagram profile, YouTube videos) • Use of modern instruments of financing tourism and innovative enterprises of the tourist sector • Inclusion of local and regional communities in the development of products and services of regional tourist economy • Preparation of educational paths Creating a tourist base
Rural-urban Commune Mogielnica	• Intelligent development of agriculture and horticulture • Development of infrastructure, regional and local transport routes • Development of service-administrative functions related to agriculture, education and culture, health protection, and social care	• Use of tools and instruments and improving technological quality of information e-systems • Use of the close proximity of outlets in the county and creating own outlet (e.g. e-commerce, digital marketing • Preparation of promotion material on websites of the city and commune, and creating own websites by residents

Table 3. Proposed directions of development and priority measures for the rural communes of the Grójec County

Name of commune of the Grójec County	Directions of development of the commune	Priority measures supported by intelligent solutions
Rural Commune Belsk Duży	• Development of competitive economy through support of local entrepreneurs and increasing investment attractiveness • Use of local environmental values to preserve the environment • Development of public infrastructure, modernisation and renovation of roads	• Consultancy in obtaining external resources for business activity • Increase in the use of energy from renewable energy resources on residential and public purpose buildings • Raising the ecological awareness of residents
Rural Commune Błędów	• Development of precise agriculture • Ecological education of residents and aesthetisation of rural areas • Development of entrepreneurial attitudes and support for business initiatives	• Striving for using high quality modern electronic and computer solutions for controlling many processes and management in an enterprise • Promoting the commune at the supralocal scale • Promotion of healthy food
Rural Commune Chynów	• Development of agriculture and agricultural-food processing with introduction of precise agriculture • Strengthening the role of producers and producer groups in the agricultural product market • Development of public infrastructure and services of the public social sphere	• Promotion and support of investments in the scope of agricultural-food processing • Marketing activities promoting local agricultural production • Support and promotion of export of fruit • Preparation and popularisation of information on support opportunities • Improvement of the quality of medical benefits and services
Rural Commune Goszczyn	• Modernisation and restructuring of agriculture, and agricultural farms in the commune • Development of pro-ecological investment • Protection of the natural environment • Rational land management	• Increase in the diversity of production in agricultural farms • Ecological education of residents and aesthetisation of rural areas • Construction of processing plants and cold storage facilities • Modernisation of horticulture production with technologically innovative equipment
Rural Commune Jasieniec	• Development of production aimed at export in the industry of advanced and medium-advanced technologies • Expansion and modernisation of infrastructure • Increase in the level of education of residents and preservation of the natural environment • Improvement of health protection	• Running all possible information channels presenting the potential of the area • Construction of a new health centre with telemedicine solutions and a rehabilitation ward • Increase in the number of cultural events for each age group • Ecological education of residents, e.g. through running educational workshops for each age group
Rural Commune Pniewy	• Development of modern methods used in agriculture • Strengthening of position in the region through opening to innovation • Development of tourism and recreation based on the natural and landscape values	• Promotion of investment land • Preparation of materials promoting the values of the commune online, mobile applications, and traditional promotion materials • Emphasising environmental and cultural values • Undertaking activities towards the development of digitisation

CONCLUSIONS

Rural areas in the Grójec County require undertaking activities for the improvement of possibilities of development of particular communes to strive for an increase in their competitiveness. Achieving economic success is related to the development of the region and giving activities an innovative character. Smart solutions increase the ability of the economy to initiate economic processes and technological progress. When innovative business becomes dynamic and evolves, it creates new situations and new means of production, modifying the existing ones. Emphasis needs to be put on the diversity of undertakings in rural areas, interactions between agriculture and other types of business activity, and combining undertakings at the local scale.

Adopting a direction of activities based on territorial competitiveness engaging the self-government administration as well as the local community in creating and using modern technologies considerably stimulates greater development possibilities of the county.

The collected data and information on the communes are of various importance for the further process of development of strategic documents. Changes in legal regulations and adopting new European standards affect documents passed locally, and indicate the direction of their updating. The changing spatial policy of communes necessitates changes in planning documents. Moreover, it contributes to promotion of rural areas, because provisions of the documents constitute information both on what the commune has, and regarding further plans on conducting the spatial development policy.

Development of modern technologies is an opportunity for the communes of the Grójec County, and a chance for an increase in innovativeness in Poland. A tool accelerating development are European Union programmes and financial resources offered in their scope, allowing for farmers to apply for subsidies for modern equipment and planned investments.

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PROPOSAL TO DESIGNATE AREAS PREDESTINED FOR THE PRODUCTION OF REGIONAL PRODUCTS – CASE STUDY OF THE MAZOWIECKIE VOIVODESHIP IN POLAND

DOI: https://doi.org/10.18509/GBP23287sm
UDC: 911.373-043.86:633/636]:528.46(438)

Katarzyna Sobolewska-Mikulska
Anna Bielska
Natalia Sajnóg
Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadaster and Land Management, Warsaw, Poland

ABSTRACT

Properly promoted traditional and regional food products can help diversify the activities of agritourist farms, increase employment in rural areas, and increase the income of rural communities. Environmentally attractive (in terms of presence of forests, waters, landscape, land use structure) locations of agritourist farms may encourage the use of the local environmental resources, and launching a business in producing e.g. honey, cheese, or meat products.

The study objective was to identify areas predisposed for the production of regional products in the Mazowieckie Voivodeship in Poland. The study employed the author's score assessment taking into account the spatial parameters of farms and plots, share of protected areas, population density, and direction and volume of agricultural production. Because the production of regional products is not directly dependent on the spatial structure of plots and farms or other factors with a significant impact on the development of intensive agriculture, it was assumed that priority areas for the production of regional products would be those where agricultural development is difficult. Given the requirement to document the tradition of production of a particular product over a period of at least 25 years, it can be assumed that the tradition of a particular direction of agricultural production is associated with the tradition of processing a particular raw material. The integration of graphic and descriptive data, necessary spatial analyses, and the visualisation of research results were prepared using the ArcGIS program.

Keywords: rural area, smart development, multifunctional development

INTRODUCTION

The production, protection, and promotion of high quality food products has been of increasing importance in the countries of the European Union [1]. One of the basic methods of implementation of the quality policy is recognition with labels confirming high quality of agricultural food products originating from particular regions, as well as those characterised by a traditional production method [2].

The system of protection and promotion of regional and traditional products is one of the most important factors in the implementation of the concept of sustainable and multifunctional rural development, and implementation of the assumptions of the II pillar of the Common Agricultural Policy [3]. It generates and contributes to the diversification of employment in rural areas through creating non-agricultural sources of income, and increases the income of agricultural producers [4]. It is particularly important in areas with peripheral location or less favoured areas (LFA), because it contributes to limiting their depopulation. The system of protection and promotion of regional and traditional products also helps protect the cultural heritage of rural areas, largely contributing to an increase in their attractiveness and development of agrotourism and rural tourism [5].

The quality policy implemented in the European Union also ensures consumers that they are purchasing very high quality food manufactured by means of an exceptional traditional method. Due to the high diversity of products introduced to the market, consumers also expect clear and exhaustive information regarding the quality and origin of the agricultural product or food article.

The production and promotion of regional products can be considered as innovative forms of activity in rural areas that allow for employment of the local community and use of the local potential.

It is a chance for producers of local, traditional, and regional food. It corresponds to the global trend of return to natural products, particularly in developed countries. Consumers show increased interest in searching for traditional and regional high quality food products, as opposed to mass production and cheap products of the food industry.

Owners of agritourist farms can take advantage of the growing interest in local food products by creating an offer for tourists based on local resources, contributing to the competitiveness of this form of tourism. This combination is a factor activating the development of agricultural farms and rural areas. It meets the needs of the urban population, creates new work places, counteracts depopulation of rural areas, causes an increase in the income of local communities, elevates their lifestyle and life conditions, and shapes a new model of consumption by the local community, as well as activates economic development. Agritourist objects that produce their own products and food have a greater chance for obtaining a larger group of clients [6].

The study objective was the identification of areas predisposed for the production of regional products in the Mazowieckie Voivodeship in Poland. The study employed the author’s score assessment method that considers the spatial parameters of farms and plots, share of protected areas, population density, and direction and volume of agricultural production.

MATERIALS AND METHODS

Study area

The study covered the area of the Mazowieckie Voivodeship in the central part of Poland, with Warsaw as the capital city, also constituting the capital city of Poland. It is a largely diverse area, comprising both areas located in the vicinity of the city and peripheral ones, considerably differing in environmental, spatial, and economic terms (Fig. 1). The research only covered rural communes in the Mazowieckie Voivodeship that struggle with problems other than those in the case of urban areas.

Figure 1. Location of the study area. Source: Own study based on the Database of Topographic Objects and the State Register of Borders

A characteristic feature of the Mazowieckie Voivodeship is the spatial variability of economic development between the metropolitan centre of the region and its primarily agricultural peripheries. Pursuant to the OECD classification, Mazowsze has been recognised as the most internally diverse region in Europe, second only to London. The voivodeship includes 105 out of 500 poorest communes in Poland. The region therefore shows extreme diversity. The Mazowieckie Voivodeship occupies the first place both in terms of the size of rural areas (94% of the area of the voivodeship) and its population (1.9 M people, accounting for 35.5% of the total population of the region). The population of rural areas in the Mazowiekie Voivodeship constitutes 12.6% of the population of Poland. Arable land constitutes 68.7% of the area of the Mazowieckie Voivodeship [7].

Study materials and methods

The identification of areas predisposed for the production of regional products involved the application of the author's score assessment of the possibility of multifunctional development combined with the possibility of producing regional products. The score assessment used the transformation index T [8] and simplified assessment of agricultural intensification of agricultural production with a division into plant and animal production. The results of the aforementioned score assessment were applied with the following assumptions:

- A. Areas with the highest preference for the production of regional products are those that should be subject to transformation first.
- B. Areas with medium preference for the production of regional products are those that require transformation. They are areas where agriculture is currently developed to a medium degree, and the structure of plots and farms is unsatisfactory.

- C. Areas with the lowest preference for the production of regional products are specified as those that require no transformation. They are areas with the best spatial structure of plots and farms

Because the production of regional products is not directly dependent on the spatial structure of plots and farms or other factors with a considerable effect on the development of intensive agriculture, it was assumed that priority areas for the production of regional products will be those facing difficulties in agriculture development. Moreover, the primary trends in agricultural production and their ranges were considered as indicators of a potential raw material used for the production of the regional product. Considering the requirement of documenting the tradition of manufacturing of a given product for a period of at least 25 years, it can be assumed that the tradition of occurrence of a given trend of agricultural production may be related to the tradition of processing a given raw material. For example in an area with a large stock of milk cattle, a tradition of milk processing and manufacturing of various types of regional products can be expected.

The magnitude of the currently conducted agricultural production was considered, as well as the share of protected areas, pointing to the possibilities of obtaining raw materials for manufacturing regional products. The share of protected areas in the total surface area of the commune was assessed on a simplified point sale ascribing 1 point to a share of 0-40%, 2 points to 41-70%, and 3 points above 70%.

The assessment of agricultural production was based on data from the Common Agricultural Census 2020 [7]. Production below the average in the voivodeship was determined as low, that at an average level as average, and that considerably exceeding average values as high (e.g. cattle stock or sawn area in a poviat in the Mazowieckie Voivodeship).

Plant production was assessed based on data regarding the sawn and crop area obtained from the Local Data Bank, Statistics Poland and data from the land and building register in reference to orchards. The sawn area was assessed on a point scale 1-3, adjusting the assessment to the average sawn area in a poviat in the Mazowieckie Voivodeship. The types of crops, average sawn areas, their assessments, and ascribed points are presented in Table 1.

Table 1. Types of crops, average sawn area, as well as assessment and ascribed points

Type of crop	Average area in a poviat in the Mazowieckie Voivodeship [in thousand ha]	Point assessment / Sawn area in reference to the average in the voivodeship [in thousand ha]		
		low – 1 point	average – 2 points	high – 3 points
total cereals	20.87	up to 20.00	20.01-30.00	30.01 and more
potatoes	0.60	up to 0.50	0.51-1.00	1.01 and more
sugar beets	0.44	up to 0.30	0.31-1.50	1.51 and more
rape and turnip rape	1.25	up to 2.00	2.01-5.00	5.01 and more
root vegetables	0.41	up to 0.40	0.41-1.00	1.01 and more
orchards in [%] share of area of orchards in total area of the commune	2.63%	up to 10.00	10.01- 30.00	30.01 and more

Source: Own elaboration based on data from [7] Common Agricultural Census

Animal production was assessed based on farm animal stock from the Local Data Bank, Statistics Poland. In reference to animal stock, a score assessment at a scale of 1-3 was applied, adjusting the assessment to the average number of animals of a given species in a poviat in the Mazwieckie Voivodeship. Animal species, average stock, and assessment and ascribed points are presented in Table 2.

Table 2. Animal species, average stock, and assessment and ascribed points

Species	Average animal stock in a poviat in the Mazowieckie Voivodeship [in thousand ha]	Point assessment / Farm animal stock in reference to the average in the voivodeship [in thousand ha]		
		low – 1 point	average – 2 points	high – 3 points
Total cattle	27.61	up to 30.00	30.01-70.00	70.01 and more
Total pigs	34.34	up to 30.00	30.00-100.00	100.01 and more
Total poultry	1049.55	up to 1000.00	1000.01-3000.00	3000.01 and more

Source: Own elaboration based on data from the Local Data Bank, Statistics Poland

The following materials were used in the study:

- a) Cadastre – data on the number of registration plots, the area of cadastral precincts in the voivodship (source: district collective statements from 2021);
- b) Database of land and building records – vector layer of the plot (source: County Geodetic and Cartographic Documentation Centres and Buildings https://www.geoportal.gov.pl/rejestry);
- c) State Register of Borders (source: http://www.gugik.gov.pl/pzgik/dane-bez-oplat/dane-z-panstwowego-reresses-granic-i-powierzchni-jednostek-podzialow-terytorialnych-kraju-prg);
- d) Statistical data from the Central Statistical Office of Poland (2010; 2020) (source: Local Data Bank);
- e) Database of the National Water Management Authority – ISOK project (https://wody.isok.gov.pl/atom_web/atom/NZ_HY_MRP).

The integration of graphical and descriptive data, necessary spatial analyses, and visualisation of study results was prepared with the application of ArcGiS software.

RESULT AND DISCUSSION

Regional and traditional products

The report of European experts [9] points to a dual direction of development for Polish agriculture. A certain share of agricultural farms has been observed to adopt production methods primarily ensuring high economic efficiency, with consideration of only the basic requirements of environmental protection, and another share of farms selects methods that are more ecosystem-friendly, using the local environmental and socio-cultural resources. The excess of working power in Polish rural areas in combination with fragmented area structure of farms and low level of education of the population results in agrarian overpopulation and increasing unemployment, consequently leading to low agricultural income and improper use of the production potential. Rural areas do offer development opportunities other than agricultural activity. The agricultural policy in Poland currently supports activities aimed at diversification of economic activity of rural population and will continue to do so in the foreseeable future. The development of non-agricultural activities in rural areas can accelerate structural transformations. The development of the local food sector, including production of regional products, strengthens local economies, reduces the carbon footprint of food distribution, contributes to the food safety of households, provides persons with low income access to quality food and healthy diet, supports small enterprises, improves rentability of small farms, etc. Local, traditional, and regional products also have a positive effect on local communities [10]. The production of food with higher health standards is characterised by high work intensity, lower efficiency, and the resulting high production cost. Traditional food products with particular quality properties constitute part of the cultural heritage that should be maintained and promoted.

Moreover, in Poland, based on the act as of 17 December 2004 on registration and protection of names and labels of agricultural products and food products and on traditional products (i.e. Journal of Laws of 2022, item 2268.) [11], the List of Traditional Products is being developed. The list includes products the quality or exceptional features and properties of which result from the application of traditional production methods, constituting an element of the cultural heritage of the region where they are produced, and an element of the identity of the local community. Production methods considered traditional are those that have been used over a period of at least 25 years. The List of Traditional Products aims at popularisation of information on products manufactured by means of traditional, historically established methods. The Ministry of Agriculture and Rural Development is responsible for accepting, assessment, and submission of applications for registration of the names, origin, geographical description, and guaranteed traditional specialties to the European Commission.

The terms regional product and traditional product emphasise the specific character of the products, referring to products themselves as well as to the place of their production (in the case of regional products). It should be emphasised, however, that tradition does not exist without a region. It is often associated with a specific ethnic group, hence there are no global traditional products [12]. Traditional products are therefore characterised by a traditional manufacturing method using traditional raw materials, native animal breeds, based on information handed down from generation to generation. The term regional product refers to its association with the natural environment of a given area (land relief, climate, type of soil). Its high quality and reputation are related to the region where it is produced, whereas the region does not have to be a region in geographic sense, but can denote the area to which the production of the product is related.

Regional and traditional products in agrotourism development

Promotion and development of production of regional products are also of key importance in the scope of provision of agritourist activity. Agrotourism and perspectives of its development constitute an important element of the rural development programme. The term agrotourism appeared in Polish and global literature at the end of the 20th century. It is defined as provision of tourist services by owners of agricultural farms combined with observation of agricultural production, hospitality, gastronomic services, and retail. Rural tourism is not synonymous with agrotourism. In addition to presenting agricultural production, it covers familiarisation with the rural lifestyle, culture, religion, traditions, etc. Separating agrotourism and rural tourism is therefore artificial. In areas with strongly fragmented agricultural production and strong rural community, it is recommended to use the term “rural tourism” [13].

Agrotourism is an example of non-agricultural development of agricultural farms and rural areas that fulfils three basic functions:

- economic (it concerns stimulation of the development of the agricultural farm, creation of additional sources of income, etc.);

- environmental (related to the protection and maintenance of the natural environment of rural areas);
- socio-psychological and social (related to the confluence of cultures, contact with the traditional way of life, etc.).

The organisation of agritourist space refers to the area of the agricultural farm, and covers land relief and architecture in the vicinity, landscape resulting from the production activity, as well as water cleanliness, noise levels, etc.

Interest in recreation in rural areas has been systematically increasing over the recent years in Poland. Particularly areas predestined for the provision of recreation and agritourism take into consideration the needs of the urban population, and contribute to an increase in the income of agricultural farms. Areas surrounding cities, including places attractive in tourist terms (water bodies, large forest complexes, historical sites, protected areas) are particularly predestined for such purposes (Fig. 2).

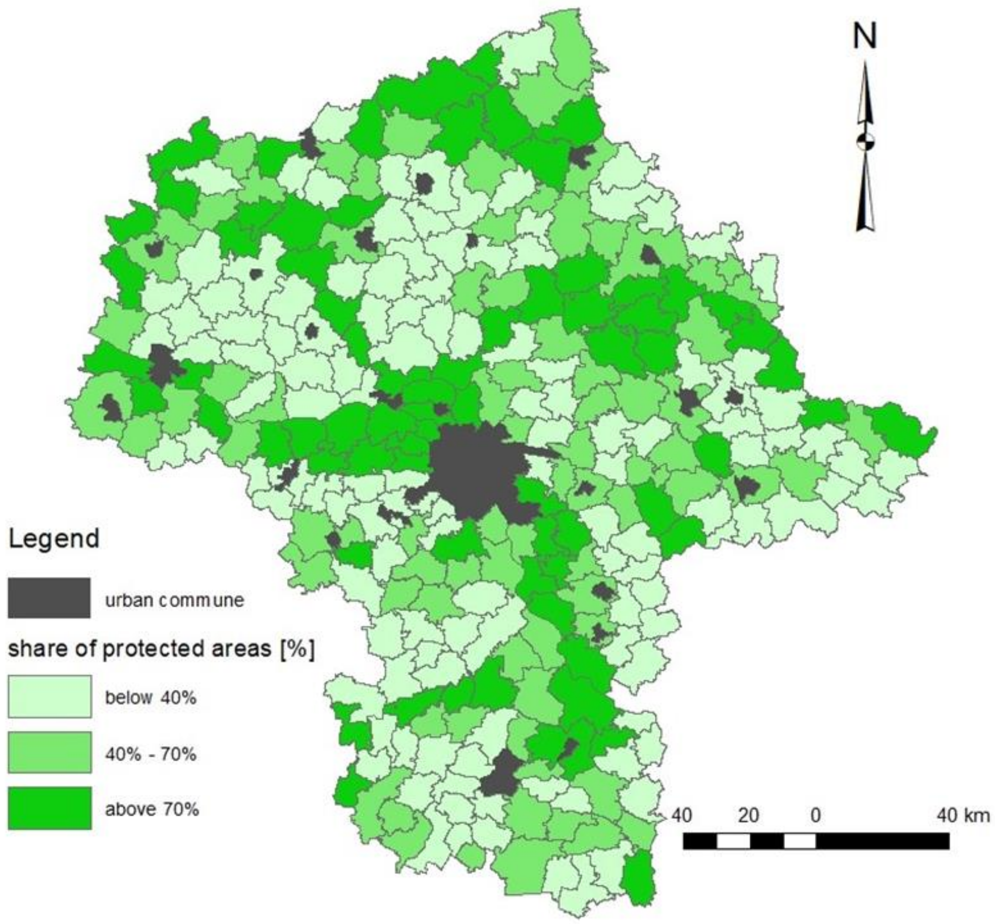

Figure 2. The share of protected areas in the total surface area of the commune
Source: Own study

Finally, it should be emphasised that many regional and traditional products are manufactured in the conditions of agricultural farms, attracting tourists and offering a chance for development of agritourism [14]. Research conducted among consumers of traditional food products shows that the place of purchase is of high importance for them, and can be used to increase its popularity. In one of the studies "Competitiveness of traditional and regional products" [15], when asked on what occasions regional and traditional products are consumed, most respondents (75% of respondents) pointed to the stay in the region of manufacturing of a given product. Only a small share of respondents could list more than five regional products, indicating the need of their popularisation [16].

The conducted research indicated areas predestined for manufacturing of regional products particularly in direct vicinity of Warsaw and other large cities, where intensive agriculture is not developed. With the assumption of possibilities of subsidising the process related to the production of the regional product, it is recommended to prioritise subsidising rural areas, and to search for the possibilities of diversification of income in such areas. Further areas considered priority are those with unfavourable spatial structure of farms and plots, e.g. in the southern part of the Mazowieckie Voivodeship, where profits from the sale of regional products could substantially contribute to the budget of households (Fig. 3).

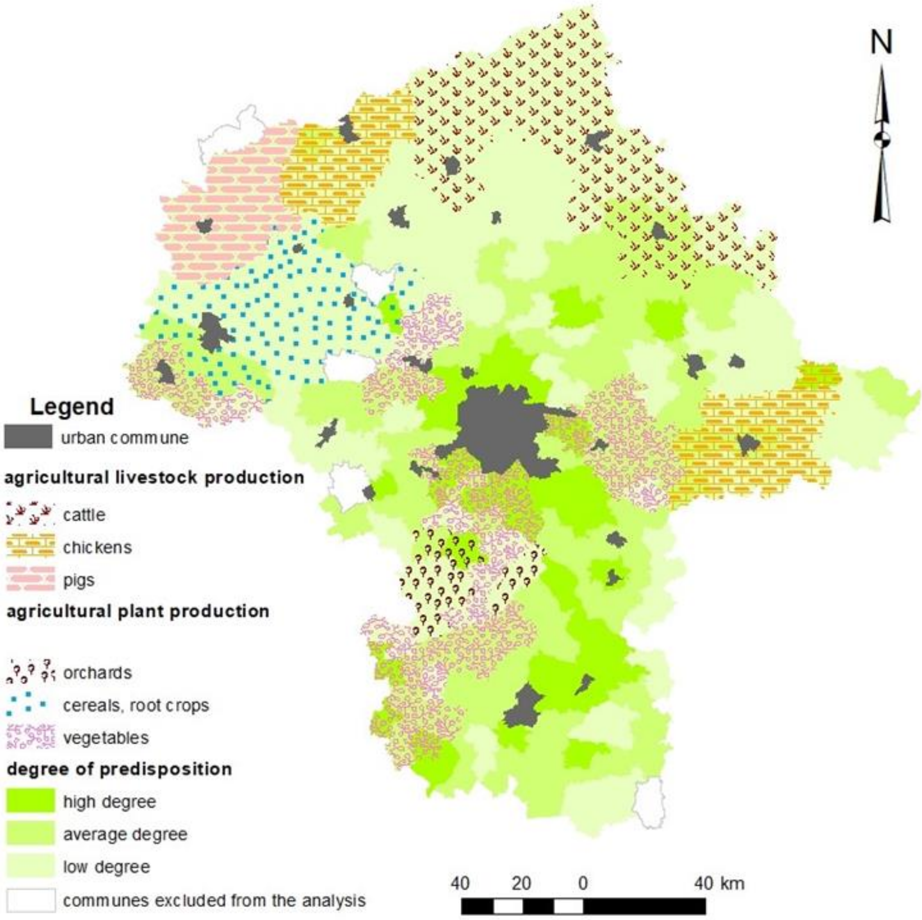

Figure 3. Areas predisposed to produce a regional products
in connection with the existing agricultural production
Source: Own study

CONCLUSION

Promotion, manufacturing, and distribution of traditional and regional food products can become an important factor contributing to the development and attractiveness of agritourism farms. Agritourist activity can alleviate the negative economic effects of tourism seasonality, and attract tourists searching for culinary experiences.

Such activity offers farmers the possibility of direct sale of their agricultural and food products. It is an effective way of increasing the income from the farm, contributing to the multifunctional development of the rural area. Appropriately promoted traditional and regional food products can help diversify the activity of agritourist farms, improve the level of employment in rural areas, and increase the income of rural communities. The location of agritourist farms attractive in environmental terms (forests, water bodies, landscape, land use structure) can encourage the use of the local environmental resources to start business activity in production of e.g. honey, cheese, or meat products.

Good cooperation between neighbours, including sharing knowledge and good practices, can become a stimulus for changes towards the development of production of regional products, associated with already existing places of occurrence of regional production. The educational factor in neighbourly relations (incidental and planned meetings, conversations), but also the application of e-technology (e.g. smartphone applications, creation of thematic websites, and traditional advertisement in the form of leaflets, articles, etc.) appears to be the most appropriate way to promote production of regional products, although the obligation of documenting 25 years of experience in manufacturing the product may be discouraging in the case of new producers. It would be of key importance to provide administrative and technical support in the scope e.g. at the commune level.

To sum up, areas predestined for production of regional products should be the following types of areas:

- where such production already takes place, and modern digital technologies can be helpful in obtaining information by persons searching for alternative sources of income,
- where agritourist farms operate with a potential to increase their attractiveness through regional products,
  where new agritourist activity can be developed, i.e. places attractive in environmental and landscape terms.
- Where the development of intensive agriculture is difficult due to the spatial conditions, ownership structure, or environmental factor, and other sources of income are sought for.

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CONCEPT OF DETERMINING THE POTENTIAL OF LAND FOR MULTIFAMILY HOUSING DEVELOPMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT – CASE STADY OF POLAND

DOI: https://doi.org/10.18509/GBP23297s
UDC: 911.375:728.2]:[528.44/.45:502.131.1(438)

Natalia Sajnóg
Dawid Zalewski
Faculty of Geodesy and Cartography, Warsaw University of Technology, Warsaw, Poland

ABSTRACT

The spatial planning system should be based on the principle of sustainable development. This in turn should lead to spatial order. The article identifies and characterises land requirements for multifamily housing development. The determination of the potential of the land involved adopting key criteria of a spatial, economic, social, and environmental character that predestine land for a given type of development. The established criteria were expertly assigned weights indicating the importance of a given parameter. The concept was tested on the example of the Białołęka district in the city of Warsaw, Poland. The potential of the analysed area was examined in terms of the possibility of development in the scope of multi-family housing with consideration of the concept of sustainable development. The study used multi-criteria spatial analysis. The analyses were carried out based on two methods, namely Weighted Linear Combination (WLC) for fuzzy criteria, and the Boolean method for hard criteria. The obtained results were visualised on a map of investment potential of the study area.

Keywords: land potential, land use, sustainable development, multi-family housing, multi-criteria analysis

INTRODUCTION

As emphasised in international reports, appropriate spatial policy is a driver of sustainable development [1-3]. Sustainable development is defined as socio-economic development involving the process of integration of political, economic, and social activities, with maintenance of environmental balance and stability of the basic environmental processes, to guarantee the possibility of meeting the basic needs of particular communities or citizens of both the modern and future generations [4]. Several dimensions have been identified in the concept of sustainable development: social [5], economic [6-7], spatial [8-10], and environmental [11-13]. Numerous studies regarding the issue of sustainable development therefore emphasise that spatial order is developed by a system of strategic goals with environmental, social, economic, and spatial character [14-15]. They stress that the traditional tools of spatial planning require urgent supplementation with new tools based on information helpful in the understanding of the increasing complexity of land and its continuous evolution and transformations [16]. An intelligent spatial planning system should be based on analyses of large data sets providing a considerably broader and multifaceted scope of knowledge in comparison to the traditional approach to planning [17]. Such activities require multi-criteria spatial analyses, broadly applicable in decision-making processes in a variety of fields [18-20]. In most general terms, spatial analyses that consider a set of criteria in decision making may be understood as a process of combining and processing geographic input data corresponding to the criteria to create a decisions map [21-23].

The article identifies and characterises requirements regarding land in the scope of multi-family housing development in the context of sustainable development. The determination of land potential involved adopting key criteria with spatial, economic, social, and environmental character that predestine land for a given type of development. The article certainly does not exhaust this broad and interdisciplinary issue. It is limited to criteria permitting obtaining current general data. The designated criteria were expertly assigned weights indicating the importance of a given parameter. The concept was tested based on the example of the Białołęka district in the capital city of Warsaw, Poland, through the assessment of the potential of the study area in terms of possibilities of spatial management in the scope of multi-family housing development. The study employed multi-criteria spatial analysis. The analyses were based on two methods, namely WLC (Weighted Linear Combination) for fuzzy criteria, and the Boolean method for hard criteria. The obtained results were visualised on a map of investment potential of the study area.

STUDY AREA, MATERIALS AND METHODS

Study area

The subject of the study was one of the districts of the capital city of Poland, Warsaw. Białołęka is a district in the north-eastern part of Warsaw. It is the city's second largest district, occupying an area of 73.04 km^2.

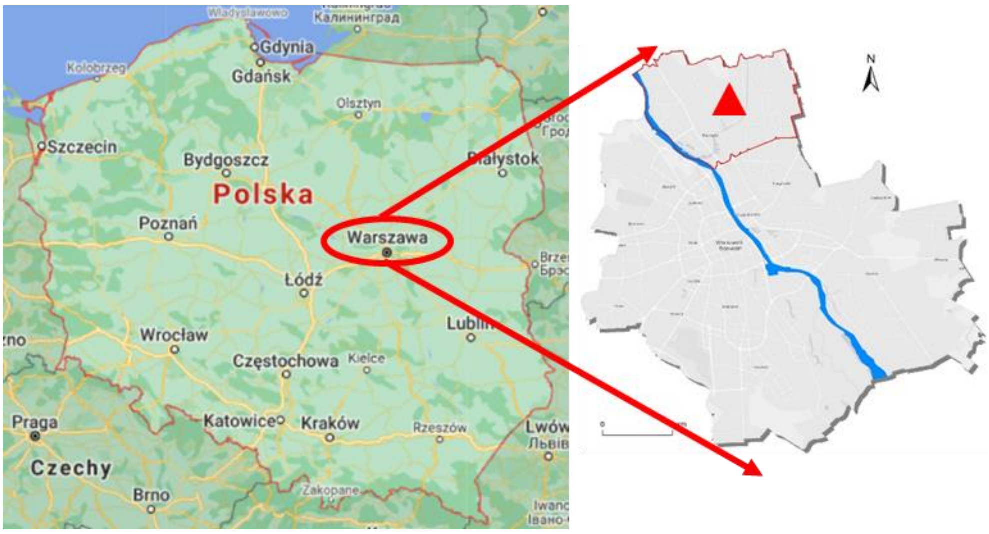

Figure 1. Map of the study area

The population of the district has been systematically growing over the years. The primary factors contributing to the population increase include high natural growth and positive internal and external migration balance. Like other marginal districts, Białołęka is a target of migration of particularly young people from peripheral areas and small towns for continuation of education or job search in the city. People living in the centre of Warsaw often move to such districts due to lower property prices and living costs.

The spatial management of Białołęka has been regulated since 1982, when the General Perspective Plan of spatial management of the capital city of Warsaw was passed. The plan stipulates an evident division between west Białołęka, where land was largely

allocated for building development, and east Białołęka, dominated by agricultural land. Since 1992, the binding document has been the General Local Spatial Management Plan of Warsaw. The plan considered the “expansion” of land with potential for housing development in the western part of the district, and accepted the possibility of urbanisation in its eastern part. Since the turn of the 20th and 21st century, the pro-building development trend in the eastern part of the district has been evident. Since then, new passed plans have been allocating a large proportion of land for building development, including multi-family housing. As at 7 January 2023, Białołęka is covered by local spatial management plans in approximately 43% (3114 ha).
Own analyses conducted based on BDOT10k show that more than half of the area of Białołęka is undeveloped land. The largest share in the management of Białołęka is reached by agricultural areas and meadows (39%). They primarily occur in the eastern part, where arable fields are interspersed by low, dispersed single-family housing. A large area of Białołęka is also occupied by forest land and tree stands (approximately 20%). Built-up land covers more than 26% of the total area of the district. It mainly comprises single-family housing that is dispersed, with clusters particularly predominant in the eastern and northern part of the district. Multi-family housing areas are mainly located in the western and south-eastern part of Białołęka. A considerable share in the development structure is also reached by industrial-warehouse areas. Their occurrence largely stems from the industrial history of Białołęka.

Materials
The designation of the predestination of land towards the transformation of the spatial structure, i.e. determination of the potential of land for multi-family housing development, employed the following data: (i) Data Base of Topographic Objects, (ii) Local spatial management plans in the Białołęka district, (iii) Digital terrain model, (iv) Ecophysiographic atlas of the Capital City of Warsaw.

Methods
Multi-criteria analyses were conducted by means of ArcGis software. The implementation of the study objective required obtaining data providing basis for the adjustment of the methodology of muti-criteria analyses, and determination of the assessment criteria. The selection of data is therefore one of the key elements of the analysis. Their appropriate selection, quality, and validity translate into the accuracy of the conducted research.
Areas with conditions most favourable for multi-family housing development were identified by determining land classification criteria with consideration of the objectives of sustainable development and the available data. The following conditions were taken into account:
- social, in the scope of distance from public purpose objects and from industrial and production plants;
- environmental, in the scope of land slope and geotechnical conditions of the substrate;
- economic, in the scope of density of public transportation stops and density of public roads;
- spatial, in the scope of the already existing land allocation in local legal documents, and distance from multi-family housing.

The analyses were conducted by means of the hard and soft method, i.e. the Boolean method and weighted linear combination (WLC). The Boolean method involved

verification of values of all criteria for binary maps in zero and one form, where 0 value denotes an unsuitable area, and 1 – a suitable area. The linear weight method involves standardisation of criteria to a continuous suitability scale in a range from 0 to 255, where zero means the least suitable area, and 255 – the most suitable area. Unlike in the case of the Boolean method, the result is not classified to one of the groups – suitable or unsuitable, but determines the degree of suitability.
The necessary stage of the analysis was ascribing weights to particular criteria. The hierarchy of importance of criteria has a considerable effect on the analysis result. The weight values should therefore be carefully designated. For the purposes of this article, the weights were determined based on knowledge from the literature on the subject, interviews with participants of the real-estate market, and own knowledge and experience.

CRITERIA OF LAND CLASSIFICATION

Due to the adopted research methodology based on the use of multi-criteria analysis for the investigation of the potential of land in the Białołęka district in the scope of multi-family housing development in the context of sustainable development and available data, the following criteria of land classification and their weights were adopted:

1. Distance from public purpose objects (10%).
2. Allocation in local legal documents (20%).
3. Distance from multi-family housing (20%)
4. Distance from industrial and production plants (5%).
5. Density of public transportation stops (15%) .
6. Density of public roads (15%).
7. Land slope (10%).
8. Geotechnical conditions of the ground (5%).

Criterion 1. Distance from public purpose objects
Public purpose objects are important places on the city map. The most important public purpose objects include among others: buildings for public administration, administration of justice, education, higher education, or health care. The availability and vicinity of these institutions are desirable for the proper functioning of the community. Figure 2 presents land suitability by distance from public purpose buildings – the closer to such an object, the more attractive the land is.

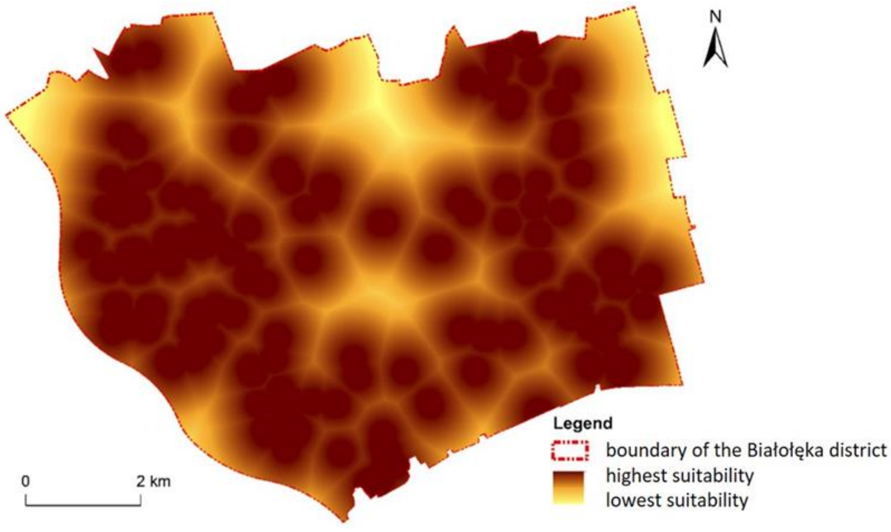

Figure 2. Land suitability by distance from public purpose objects

Criterion 2. Allocation in local legal documents

The local plan provides the basis for spatial planning and directly affects the purpose and conditions of land management, and therefore the potential of land for multi-family housing development investment. In the plan, land allocated for potential implementation of multi-family housing development is marked as suitable, and the remaining land allocated for another form of development or not covered by the local plan – as unsuitable.

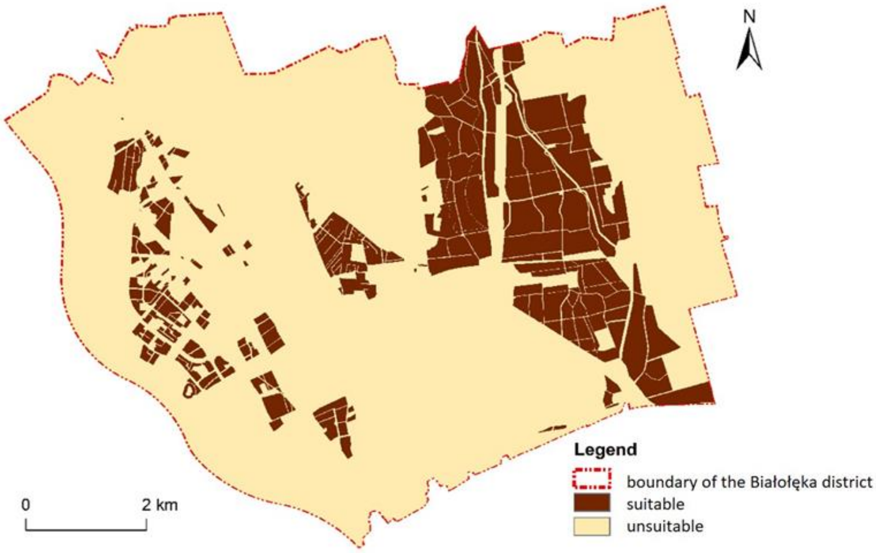

Figure 3. Land suitability by allocation in local legal documents

Criterion 3. Distance from multi-family housing

In the case of lack of the local spatial management plan in a given area, the conditions of building development are determined by an administrative decision issued on request of the investor, i.e. decision on the conditions of building development. One of the conditions of obtaining the decision is the application of the so-called rule of good neighbourhood in the context of the existing building development and networks of utility lines. The analysis deemed land at a distance of up to 150 m from the existing multi-family housing suitable, whereas the smaller the distance, the better.

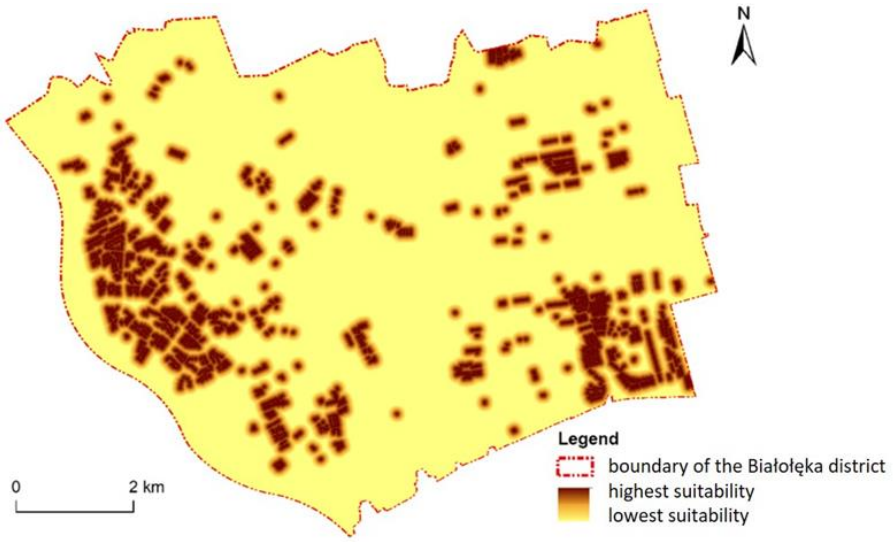

Figure 4. Land suitability by distance from housing

Criterion 4. Distance from industrial and production plants
Due to the previous industrial character of the district, the area of modern Białołęka includes many industrial as well as production and postproduction plants. The presence of such objects in the neighbourhood of building development is commonly sociably undesirable. It decreases the attractiveness of the land. The analysis involved the demarcation of areas at a distance of up to 100 m from production and industrial plants as unsuitable, and those at a higher distance as suitable.

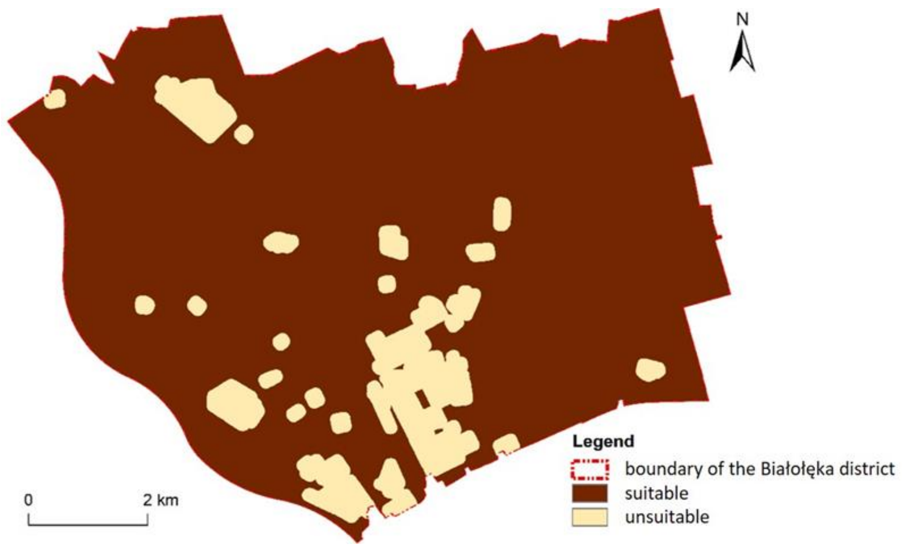

Figure 5. Land suitability by distance from industrial, production, and postproduction plants

Criterion 5. Density of public transportation stops
Vicinity of public transportation stops is key in the context of decisions of potential purchasers of apartments. A small distance from collective transportation stops offers the possibility of fast commute, and an alternative for car travel.

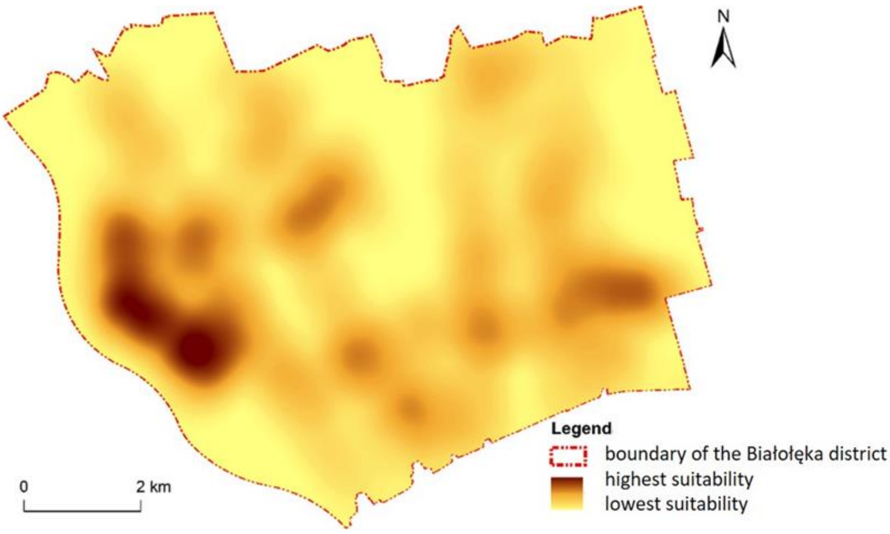

Figure 6. Land suitability by density of public transportation stops

Criterion 6. Density of public roads

Land located directly at a public road does not require the investor to build new access roads to the planned investment. Therefore, it does not increase the financial expenditure, or “take” the building space. For a resident, purchasing an apartment near the already existing roads is important due to the better developed technical and transport infrastructure at main roads, and due to the vicinity of various services.

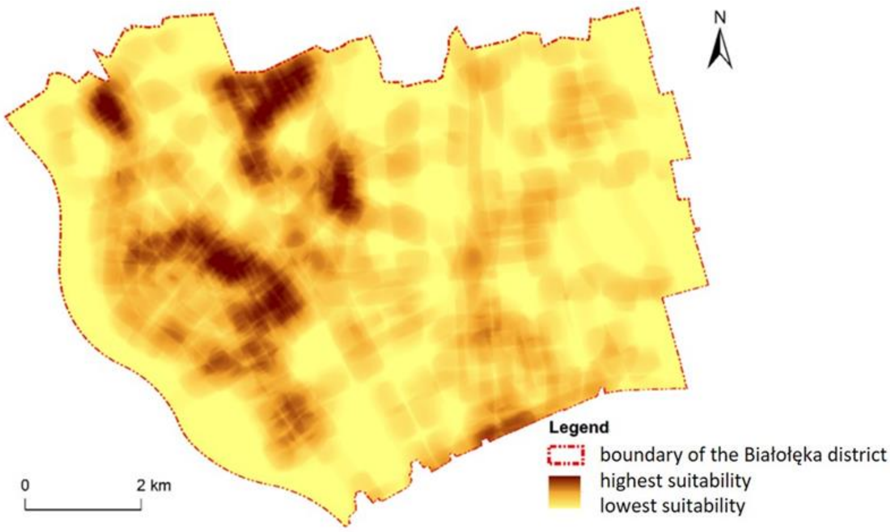

Figure 7. Land suitability by density of public roads

Criterion 7. Land slope

In the case of planning an investment, land relief is an important factor in decision making regarding the location of housing development. Situating buildings on land with a steep slope generates additional costs related to among others surface levelling for the investment. By land slope, the suitability of land for building development can be classified as follows: (i) slope 0-3°– land suitable for unlimited building development, (ii) slope 3-5° – land suitable for building development with restrictions of after adaptation, (iii) slope above 5° – land unsuitable for building development [24]. The analysis deemed land with a slope of up to 5° suitable for building development, whereas the smallest the slope the better.

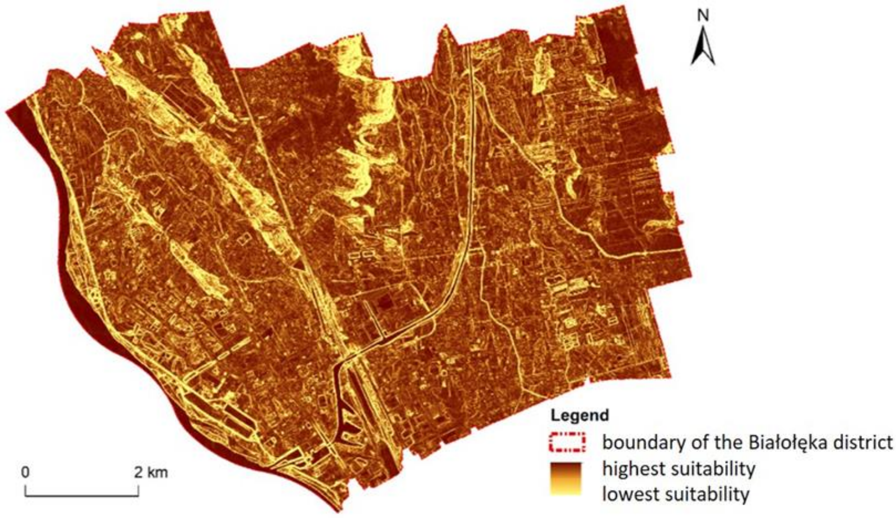

Figure 8. Land suitability by land slope

Criterion 8. Geotechnical conditions of the ground
Areas of occurrence of weak bearing ground and shallow groundwaters, as well as other soil conditions unfavourable for building development are particularly problematic. Some of the areas require advanced ground works to become suitable for building development. It requires incurring additional financial costs. The following were classified in the district: (i) weak bearing ground, (ii) anthropogenic ground with a thickness of more than 1.0 m, (iii) ground with an aquifer up to 2.0 m b.g.l., (iv) wetlands. They were marked as unsuitable in the analysis.

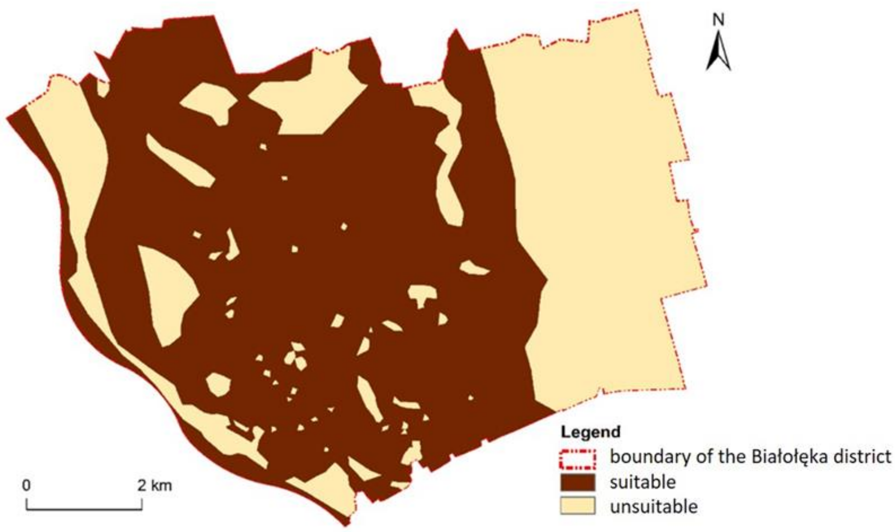

Figure 9. Land suitability by geotechnical ground conditions

RESULTS AND DISCUSSION

As a result of implementation of particular criteria, eight rasters were developed. They were then combined into a single resulting raster. A map of land suitability for multi-family housing development was obtained. Green colour visualises land with greater suitability, ad brown colour land with the lowest suitability. The most suitable land is primarily located in the western and south-eastern part of the district. The analysis shows that areas with the lowest degree of suitability are concentrated along the Vistula River (western boundary of the district), in forest areas in the northern part of Białołęka, in the area of industrial complexes in the central-southern part of the district, and in its eastern part, characterised by weaker geotechnical ground conditions.

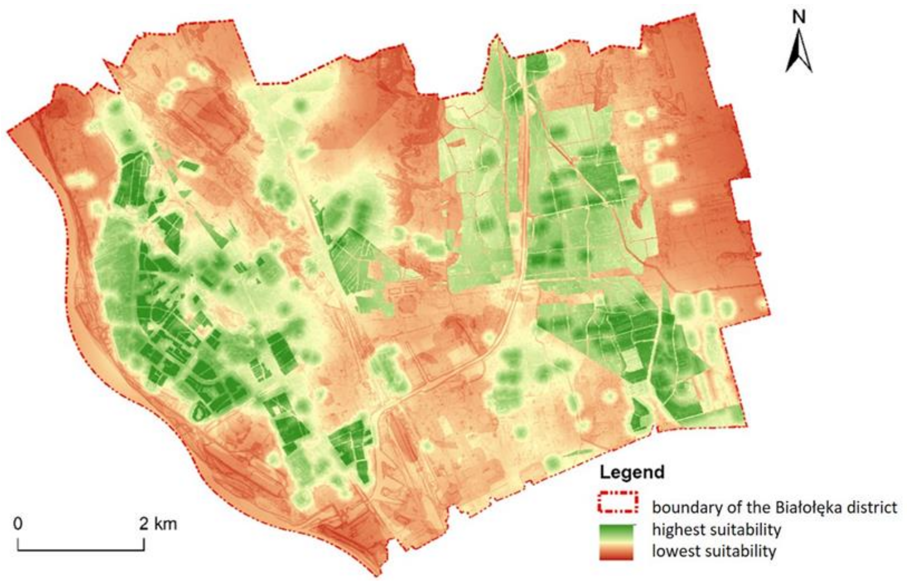

Figure 10. Land suitability for multi-family housing development

The assessment of the actual potential of land required the development of so-called exclusion mask, i.e. designation of areas where multi-family housing development is not possible. It was assumed that the limitations result from another land purpose in local spatial management plans and twelve layers of the base of topographic objects (BDOT10k), i.e. 1. sports structures, 2. cemetery structures, 3. technical structures, 4. other structures, 5. built-up areas, 6. surface water areas, 7. forest areas and tree stands, 8. permanent cultivation areas, 9. protected areas, 10. transportation and transportation service areas, 11. waste dumps, 12. excavations and spoil dumps.

The aforementioned barriers considerably narrowed down the area predestined for multi-family housing development. The final map of land suitability shows a general deficit of land for building development in the western part of the district. These areas are fragmented, and most of them show low suitability. In the central-eastern belt of Białołęka, there is, however, a considerable reserve of land where multi-family housing development can be implemented. The land is only partially covered by local spatial management plans permitting the analysed type of building development. The areas, however, require greater investment in technical infrastructure.

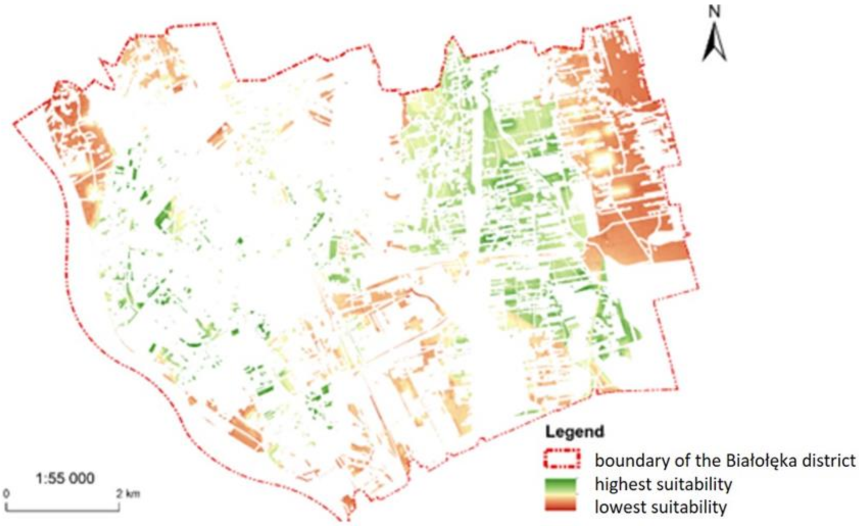

Figure 11. Land suitability for multi-family housing development

CONCLUSIONS

The proposed concept of designation of areas predestined for multi-family housing development is based on the priorities of sustainable development. This means that in the scope of the analysis of land suitability, the criteria of economic (including infrastructure), spatial, and environmental character cannot constitute the exclusive conditions of the choice. Criteria with social character are equally important. The range of criteria itself remains open, and dependent on the availability of data and land specificity.

Sustainable development is synonymous with harmonious growth which taps into the space's full potential through a proper spatial policy conducted by the authorities with the use of planning instruments [25]. Therefore, an effective spatial planning policy should strive to improve the quality of life of residents by eliminating transforming or changing space [26-27]. The application of intelligent solutions should provide the basis for making justified urban planning decisions. The introduced structural and spatial changes should be based on the concept of sustainable development with the application of intelligent methods and tools of development and respect for the social aspects.

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SECTION

TEACHING & EDUCATIONAL GEOGRAPHY

FROM THE BASIC TO THE LONG-TERM KNOWLEDGE OF GEOGRAPHY: EXAMPLE ON URBAN GEOGRAPHY CONTENT

DOI: https://doi.org/10.18509/GBP23311d
UDC: 37.016:911.375-047.4

Filip Domaćinović[1]
Ružica Vuk[2]
[1]I. gimnazija Osijek, Department of Geography, Faculty of Science, University of Zagreb, **Croatia**
[2]Department of Geography, Faculty of Science, University of Zagreb, **Croatia**

ABSTRACT

Understanding how geographical knowledge is created and retained in educational geography in Croatia is, for now, poorly researched. The aim of this research is to examine the level of retention of geographical knowledge and skills for a chosen outcome. During the school year (SY) 2021/2022, in seven schools with a high school program in the Osijek-Baranja County, at the end of the learning and teaching process, an exam on the retention of the outcome GEO SŠ C.B.3.2 was carried out. 420 students participated, with average score being 48.81%. In the first semester of the following school year, a new exam was carried out with the same sample (428 students) for the same outcome. A written exam contained eight items, with the average score being 44.95%. By using the focus group method, exam tasks were agreed upon by teachers of Geography in schools of the researched area, while one evaluator conducted the evaluation. The results indicate students can recognize elements of the city system well, distinguish between elements of a smart, sustainable and inclusive city, and recognize the urban heat island while suggesting possible measures for its mitigation. In test items where a higher cognitive level is expected, the results are significantly weaker. Using Maude's typology of PGK, we can conclude that student knowledge retention is good for types 1 and 4, while type 2 is below average. This research is a continuation of research started in SY 2021/2022. By comparing the research results for seniors (470 students) of the SY 2021/2022 and the seniors of the SY 2022/2023, we conclude that the results are very similar (average score of 50.48%).

Keywords: educational geography, Maude's knowledge typology, knowledge retention, curriculum

INTRODUCTION

If a school is an institution the task of which is to achieve the educational goals set by the school curriculum, and education is "the most important available tool for encouraging a deeper and more harmonious human development" [15] then it is of crucial importance to have a good understanding of the ways of creating and retaining knowledge in the minds of students. Cognitions about the creation and retention of knowledge would enable teachers to have greater control over the educational process in classrooms, as well as the application of those teaching methods that would ensure the creation of permanent knowledge at the appropriate cognitive level.

In the focus of this paper is the teaching of geography in the Republic of Croatia, which has undergone significant changes in the past four years with the introduction of a new curriculum for the subject Geography and a curriculum of cross-curricular topics. The new geography curriculum in Croatia brought changes in the content, but also in the methods of teaching geography in elementary schools, high schools and high schools with a grammar school program. With the goal of developing the fundamental values taught by Geography in students' and making them conscientious members of the community and builders of a better future for the Republic of Croatia, Europe and the world, the new curriculum is structured according to four concepts within which educational outcomes are organized. The student will adopt them throughout the education process guided by the teacher using modern teaching methods and tools, which encourages the development of critical thinking, problem-solving skills, increases their satisfaction, but also the motivation of both teachers and students [2]. Still, it is yet to be determined what effects this reform will have on the geographical skills and knowledge of students who have studied geography according to the new curriculum in all school years during their education. The introduction of a new geography curriculum in vocational schools is imminent in the Croatian educational system. Therefore, it is necessary to improve the understanding of the process of creating and retaining geographical knowledge in order to further develop and improve geographical education. Vocational education reform takes place within the project of Modernization of vocational education and training systems [13]. The aim of the project is to develop innovative and flexible sectoral and vocational curricula based on the needs of the labor market while strengthening the competences of educators for the introduction and implementation of the curriculum, as well as the development of vocational education and training that is attractive, innovative, relevant and connected to the labor market.

Understanding how geographical knowledge is created and retained in educational geography in Croatia is, for now, poorly researched. Therefore, the goal of this research is to examine the level of retention of geographical knowledge and skills on the chosen outcome through two different written tests of initial knowledge (knowledge from the previous school year) conducted in two different school years, thus determining whether the cognitive level of the set outcome and/or "power" of geographical knowledge affect the retention of knowledge. The determination of the "power" of geographical knowledge will be done using Maude's typology for powerful geographical knowledge [9] while the cognitive levels for the observed outcome will be determined from the geography curriculum for high schools. The selected outcome GEO SŠ C.B.3.2. belongs to the concept of Sustainability and reads: The student analyzes the city as an organized system, investigates the causes of temperature differences in the city and proposes ways and measures of sustainable development of cities. In the elaboration of the outcome, it is specified that by adopting this outcome, the student will be able to describe the elements of the city system (traffic system, waste management, energy system, land usage), investigate the causes and consequences of the existence of the city microclimate, distinguish the characteristics of a smart, inclusive and sustainable city, as well as identify the elements of a sustainable city (environmental, economic and demographic sustainability) on the example of the hometown [14]. If the ideas of the new curriculum are well applied, and given that the new curriculum promotes the development of critical thinking skills and problem solving (not only in the subject of Geography), it is to be expected that there will be no significant differences between the results in tasks that test knowledge and skills of lower and higher cognitive levels. Maude's typology of powerful geographic knowledge will be included in this research with the aim of observing the new curriculum through the prism of "perhaps the most important debate that has appeared in educational geography in the past few years" as well, referring to determining what powerful geographic knowledge really is [11]. By analyzing the results of this paper, it will be determined which of Maude's five types of powerful knowledge correlate with those in the selected outcome and how successfully the students managed to retain that knowledge.

AN OVERVIEW OF THE SELECTED RESEARCH

Few authors dealt with the topic of retention and creation of knowledge in educational geography in Croatia. From the work of Ivić and Vuk [4], in which an overview of works related to geography methodology and educational geography in the last five decades in Croatia is given, we can identify works related to this research, and these works are found in the category of works whose primary theme is student achievements. According to the topic of knowledge retention and partly methodology, one paper stands out. It is the work of Grofelnik and Pap [3], which is very similar in terms of applied methodology to this paper. The authors used an initial exam of cartographic knowledge and skills among high school students in first grade in three selected high schools with a grammar school program in the area of the City of Rijeka. They conducted an analysis for the written exam as a whole and for each question separately and evaluated the average results, differences in results according to groups of theoretical knowledge and cartographic skills and differences in results according to the categories of factual, conceptual and procedural knowledge. According to the average result for the entire written test in all observed schools of 31.6% and the differences in the results of test items for checking factual knowledge (66%) and cartographic skills (22%), the authors concluded that "mastery of permanent cartographic knowledge and skills of students after elementary school is very low" [3].

In the group of papers on student achievements since 2000, there is a significant number of those dealing with the topic of analyzing the results of national matura exam and other external evaluation exams [16, 17, 18, 19, 20, 21] the methodology of which, relating to the analysis of individual test questions, is useful as a guideline in the analysis of individual questions conducted in this paper.

Other than the aforementioned paper by Ivić and Vuk, Hrčak (Portal of Croatian Scientific and Professional Journals) was used to review published papers in the Republic of Croatia. Only one paper dealing with the research of retained knowledge was found, by the authors Latin et al. [8]. The authors of the paper investigated the differences in the retention of knowledge in biology lessons among students of second grade during the application of different teaching methods in the Third High School Osijek. Two different teaching lessons were chosen, which were covered in two different ways (two different teaching methods used predominantly) in four different classes. Through three exams (initial, final and repeated final exam), the authors found that students which covered the lesson content using the conceptual maps achieved better results on exams and solved issues related to higher levels of knowledge better compared to the other group of students not using conceptual maps in same lessons, whereby their prior knowledge was at a similar level. Regarding the retention of knowledge, the group of students who worked with conceptual maps achieved better results on the repeated exam conducted during the following school year. The overall results in repeated exams in both observed groups were still worse than those analyzed in final testing when the teaching content was still fresh in students' minds, i.e., at the time immediately after learning and teaching process [8].

The second goal of this paper is to link the obtained results with Maude's knowledge typology. Given the novelty of this typology and the whole debate on powerful geographical knowledge, it is not surprising that there are no papers dealing with this typology in Croatia. Also, there are no similar formulations that will observe geographical knowledge in that way. Perhaps the reason is that curricular developments in Croatia are still far away from that level of observing geography. In the paper by Lambert et al. [7], who are among the first to give an overview of the concept of powerful geographical knowledge, three concepts can be observed: Future 1, Future 2 and Future 3 curriculum. Observing geography through the prism of powerful geographic knowledge can be found only in the last one (Future 3). Future 1 curriculum implies those curricula the orientation of which is on stale and factual knowledge that teachers in classrooms needs to pass on to students. It is the traditional way of teaching and this, according to the authors, makes geography boring. The Future 2 curriculum is oriented towards the outcomes that the student needs to achieve through independent learning in which the teacher is a "guide" for students towards the sources of knowledge. The authors also mention the phrase "learn how to learn", which is often mentioned in new curricula in Croatia. They are not in favor of that form of curriculum either and they find the solution in the Future 3 curriculum, which is between the pure factography of the first one, but also for the abandonment of the less important role of the teacher in the second. According to them, the teacher must be a person who brings forth that powerful geographical knowledge [7].

Maude engages in this debate created over Young's idea of powerful disciplinary knowledge with the desire to define what powerful geographical knowledge really is. Young believes that the goal of schooling should be to create such knowledge in students that allows them to think and reason beyond the boundaries of their environment and experience [11]. Analyzing what other authors have written in the current debate [9, 10, 11, 12], Maude presents five types of powerful geographical knowledge. According to him, there are a lot of analyses of the idea of powerful geographical knowledge [11], but few have tackled defining what it really is and how to integrate it into the education of geography i.e. in the new curriculum. According to Maude's [11] paper, the subject was dealt with only by Lambert in 2011 [5] and 2014 [6]. Maude sees two ways to define powerful geographical knowledge. One starts from the approach of determining what in a discipline (in this case geography) is of good quality, and the other sees powerful knowledge as a set of skills, knowledge or abilities that this knowledge will bring to a student if they master it [11]. In this way, Maude composed five of those types of powerful geographical knowledge, in the following order:

1. Knowledge that provides students with new ways of thinking about the world.
2. Knowledge that allows students to analyze, explain and understand the appearance of the processes around us.
3. Knowledge that gives students power over their own knowledge i.e., the power of self-reflection.
4. Knowledge that enables students to, as members of their communities, follow and participate in ongoing debates on significant local, national and global issues.
5. Knowledge of the world i.e., parts of the world which are not their immediate surrounding. [9]

RESEARCH METHODOLOGY

As part of the longitudinal research and observation of the changes brought by the new curriculum in the first years after its experimental and subsequent frontal introduction into schools with a high school program, in the area of Osijek-Baranja County, written exams testing adoption of selected outcomes are being carried out for the second year in a row, one of which is GEO SŠ C.B.3.2 mentioned in this paper. The schools involved in this research are First High School – Osijek, Third High School – Osijek, Jesuit Classical High School – Osijek, Đakovo High School, Valpovo Secondary School, Donji Miholjac Secondary School, and “Isidor Kršnjavi” Secondary School – Našice. This encompassed 11 teachers and approximately 900 students in two generations who, during the school years 2021/2022 and 2022/2023, wrote three different written exams of geographical knowledge and skills. The test materials were compiled by the authors of this paper, after which they were presented to the teachers who teach geography in the selected schools using the focus group method before each written exam. The teachers had the opportunity to make their suggestions regarding the exam materials, which were then corrected if necessary. After the exam, evaluation of the answers was conducted by only one evaluator. The first exam that was taken in September 2021 by the 4th graders (the generation enrolled in the high school in SY 2018/2019) was of the initial type of knowledge check and contained seven questions that checked the adoption of the GEO SŠ C.B.3.2 outcome. In May 2022, a second exam was conducted, which determined the adoption of the same outcome, but this time in the third grades (the generation enrolled in the high school in SY 2019/2020) for whom this was the content learned and taught in that school year. This written test had six questions that checked the adoption of the aforementioned outcome and it was possible to achieve a total of 7 points, as was the case in the exam from September. The last exam of geographical knowledge and skills was carried out in November 2022, when the fourth graders of the time (the generation enrolled in high school in SY 2019/2020) demonstrated how much knowledge and skills from the observed outcome they retained in their memory in eight questions because this, too, was an initial exam. The tests were not announced to the students and they were not specially prepared for them. It should be emphasized that the tasks were not the same, but they checked the same outcomes from elaboration of GEO SŠ C.B.3.2. outcome and tested different levels of knowledge.
After the exams were graded, the average success rate (arithmetic mean) of all the questions that tested the adoption of the GEO SŠ C.B.3.2 outcome was calculated. The same was done for average success rate on each individual question item and the average success rate of the individual questions according to cognitive levels of knowledge they tested. At the end of the analysis, individual question items were classified according to Maude's typology of powerful geographical knowledge. Each question got assigned one of the five types it represents, and after that it was observed in which question the students achieved better results. Using the results of research conducted on the same sample of students and at the same time [2], the connection between the results of the written exam and the teaching methods that teachers often use in classrooms was determined as well.

RESULTS

The focus of this paper is the retention of geographical knowledge and skills. Therefore, the results of exams conducted in May and November 2022 will be more interesting in the analysis because they refer to the same generation of students (enrolled in the high

school in the SY 2019/2020). In May 2022, 420 third graders took part in written tests of knowledge and skills, while in November the number of respondents was 428 students. The sample is almost the same, so the results are comparable. At the test in May when the students actually reproduced the knowledge that was current to them at that moment, the question tasks that checked the adoption of the outcome GEO SŠ B.3.2. were solved with a 48.81% success rate, which can be considered a satisfactory result. It was expected that in the initial exam in November, students (who attended the fourth grade at the time) will perform worse due to the time gap from the moment they learned the examined content. With a result of 44.95% success rate, we can conclude that the retention of knowledge is at a high level. If we compare the results of the exam done in November 2022 with the generation surveyed in 2021, we notice that better results in initial exam were achieved by the older generation of students. Their average score was 50.48%. The reason for such a result could be found in the structure of exam i.e., in the types and formulations of tasks. The initial exam written in November 2022 contained a total higher number of questions and had a higher number of questions at higher cognitive levels, with particles at the application level of Bloom’s taxonomy done at a significantly worse success rate.
Through further analysis of the individual questions of the written exam, they were classified according to cognitive levels of knowledge in the revised Bloom's taxonomy [1] (Table 1). In an initial written exam conducted in September 2021 written by a generation enrolled in the high school in SY 2018/2019, a total of seven questions checked the adoption of the outcome. Of these, two questions examined the lowest cognitive level of knowledge, two questions examined the cognitive level of understanding, and three questions the cognitive level of application in Bloom’s taxonomy. The exam taken by the generation enrolled in the high school in May 2022 also had two questions that examined the acquisition of knowledge of the lowest cognitive levels, while the cognitive level of understanding was examined by three questions and the cognitive level of application by one question. A written exam conducted in November 2022 had two questions that examined lowest cognitive level of remembering, four questions that tested the cognitive level of understanding, and two questions that tested cognitive levels of application (which includes higher cognitive levels of knowledge).

Table 1. The structure of written exams according to the number of questions and cognitive levels of the revised Bloom's taxonomy

Date/time of exam	Remembering	Understanding	Application
September 2021	2	2	3
May 2022	2	3	1
November 2022	2	4	2

Furthermore, the average success rate of resolution of test questions according to cognitive levels was compared (Figure 1). In all three exams, the parts solved at the highest level of success were the questions that examined the elements from the elaboration of outcomes at the cognitive level of understanding (55.89%), which is encouraging for the realization of the curriculum at the planned level. The test questions that tested the cognitive level of remembering had the worst success rate (33.95%), perhaps due to the fact that they tested the memorization of new terms or syntagms specific for the subject with short answer tasks. They are also interconnected in the exam so the solving of the second depends on the solving of the first question. To check the knowledge on the cognitive level of understanding, the following question types were used in all three exams: three multiple-choice tasks, one matching task and six short-answer tasks. This means that a significant proportion of the exams was made up of closed-type tasks, and no extended-response task was used from open-type tasks. Test questions that checked the cognitive level of application were better solved in all three conducted exams compared to questions that had the function of checking the adoption of knowledge for the cognitive level of remembering, and weaker than those that tested the cognitive level of understanding. Another argument in favor of better acquisition of knowledge at higher cognitive levels could be related to the results of a study conducted on the same sample which found that, in the schools included in the research, the dominant teaching method was the discussion method followed by an indirect graphic method and work-on-text method [2]. All three teaching methods can encourage students to reflect and talk about certain topics. For students, this results in retaining in permanent memory the basic knowledge about the topic, but poorer memory of new terms because students did not encode them with sufficient quality (deep learning was absent). Further research should check the possible positive impact of the application of conceptual maps in teaching and learning of new subject terminology.

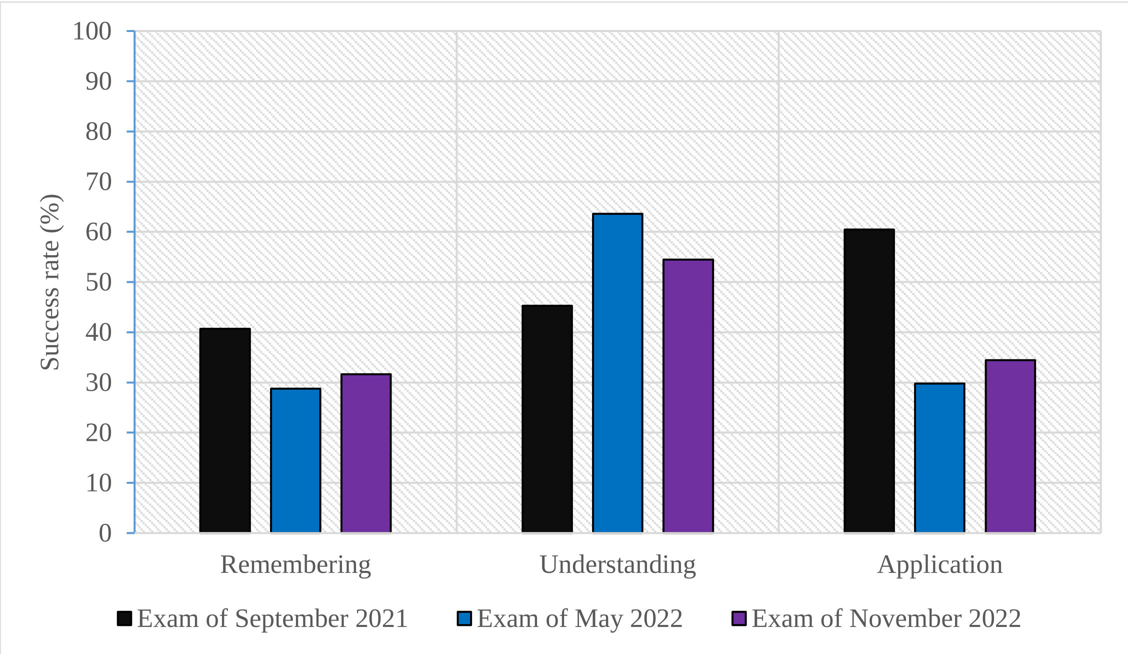

Figure 1 - Average success rate in test questions for the outcome SŠ C.B.3.2., according to cognitive levels of Bloom's taxonomy in all three exams carried out

In an exam conducted in November 2022, we note a high degree of knowledge retention (54.46%) in test questions that tested for the cognitive level of understanding (54.46%), and a satisfactory level is also present in questions that have tested the cognitive level of application in which the average success rate was 34.46%. The particles that examined the cognitive level of remembering at 31.66% success rate are at the limit of what could be considered a satisfactory retention of knowledge. It is also interesting to note the anomaly that students scored better results in test questions that examined cognitive levels of remembering and application in an exam conducted half a year after teaching, in November 2022, than the exam conducted in May 2022, immediately after the learning and teaching process. One of the possible reasons could be the time when the exam was conducted. It was the part of the school year in which a large number of written exams of knowledge in most subjects take place, which could affect the reduced motivation of students in solving test materials that were not evaluated with a numerical grade in the subject of Geography in that school year.

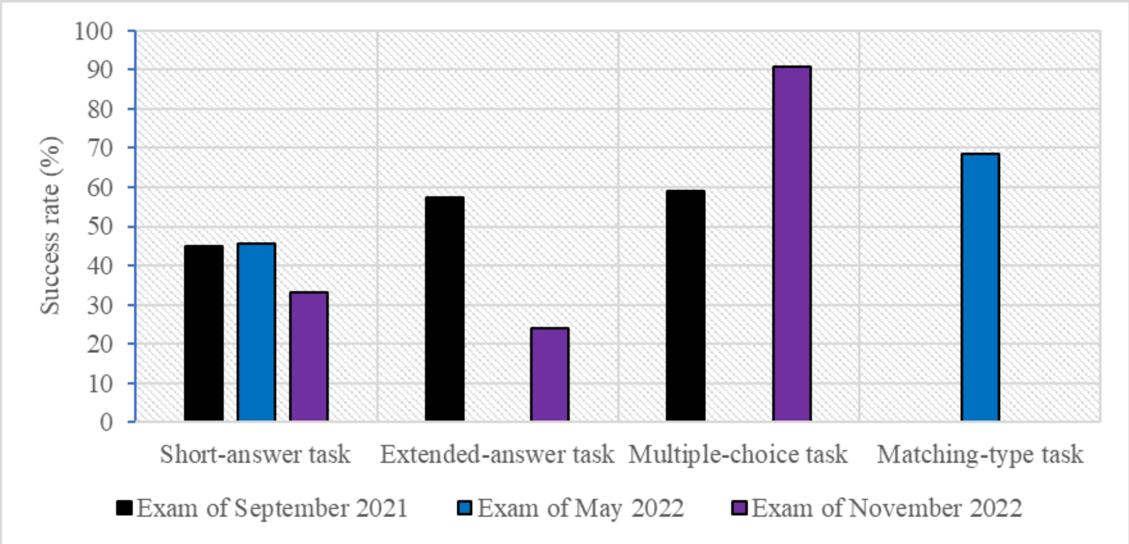

Figure 2. Average success rate on test questions for the outcome SŠ C.B.3.2. by types of tasks in all three exams

Different types of questions were used in the three written exams (Figure 2). Open-type tasks (short-answer and extended-answer) were used in each exam, while the matching type task was present as a closed-type task only in one of exams and multiple-choice tasks in two of three exams. As expected, the multiple-choice tasks (79.53%) and the matching-type task (68.45%) were solved most successfully. Among the open-type tasks, extended-response tasks (46.96%) were more successfully solved than short-response tasks (40.8%). Comparing the results of the generation enrolled in SY 2019/2020 in both exams (in May 2022 and November 2022), we can conclude that they solved multiple-choice tasks most successfully, and the weakest success rate was noticed in the extended-response task. The above is not surprising considering that in closed-type tasks there is the possibility of guessing the correct answer, the possibility of recognizing the correct answer among the ones offered, as well as the application of the technique of eliminating incorrect ones among the offered answers. For example, here is a type of multiple-choice task in which students had to carefully observe the offered features and circle one of the offered options that does not make the city an inclusive one. The features offered were a ramp for the disabled, low-floor trams, accessible pedestrian signals and natural gas-powered bus. Another example is that of a matching-type task in which students had to connect the terms inclusive city, sustainable city and smart city with photos that showed some of the characteristics of such a city. In the questions where extended-response tasks were used, the results were weaker in those questions which tested the outcome at the cognitive level of application. In the questions in which short-answer tasks were used, those in which new terms were tested at the cognitive level of remembering or cognitive level of application in new situations were solved with a lower success rate. Therefore, we can conclude that the students did not adopt subject terminology so well and are better at tasks in which something needs to be described in longer terms. This enabled them to receive at least a part of the possible points and achieve better results by showing an understanding of the phenomenon in tasks with extended answers.

In the end, the success rate for individual questions and full exams carried out in May and November 2022 was analyzed using Maude's typology. Out of the seven test particles used in the exam in May 2022, two were classified into type 1, four into type 2 and one into type 4. The three questions from the exam conducted in November 2022 were classified into type 1, three into type 2 and two into type 4. In the exam conducted in May 2022, the most successfully solved questions were those that could be linked with type 2 powerful knowledge and the other two types, type 4 and type 1 knowledge, were really similar in success rate but tested below type 2. Immediately after learning and teaching the outcomes of GEO SŠ B.C.3.2., students were most successful in proving the knowledge that allows them to analyze, explain and understand the phenomena and processes in the modern world. In contrast to the above, in the exam carried out half a year after the learning and teaching process of the GEO SŠ B.C.3.2 outcome, the most successfully solved were those questions classified into type 1, slightly weaker were the questions associated with type 4 and significantly weaker success rate was noticed in questions classified as type 2 powerful knowledge. This established that the students most successfully retain the knowledge that allows them to think about the world in different and new ways and that enable them to be involved as members of the community in ongoing debates at the local, national and global level. Given that the students come across and understand the content of the examined outcome for the first time during geography education in the third grade of high school education, a good mastery of this content is very important for understanding contemporary changes in urban settlements and making informed decisions to improve the quality of life in them.

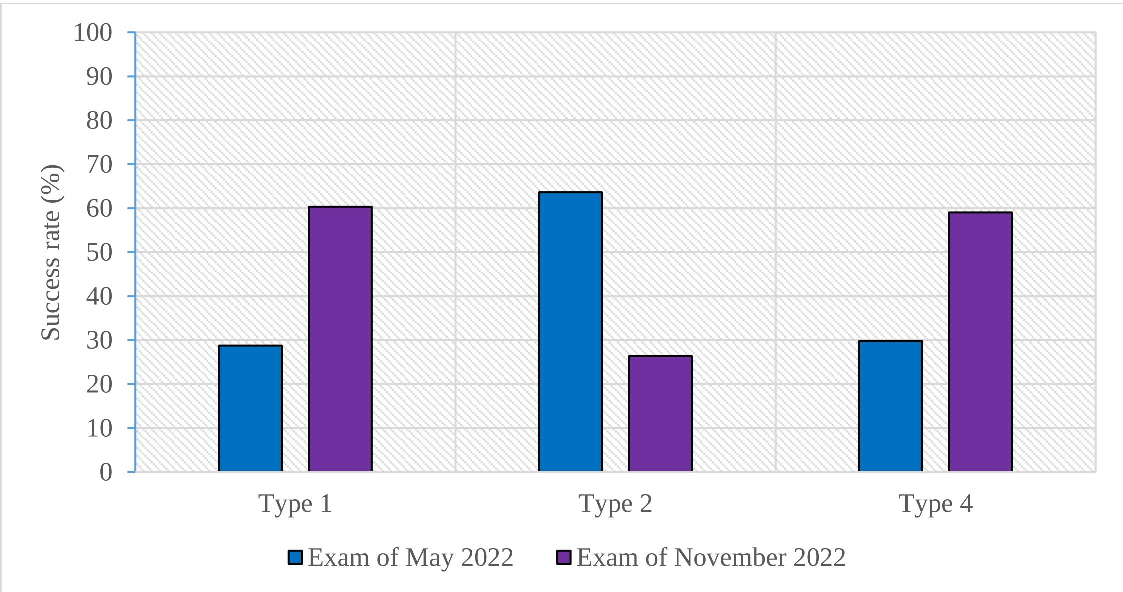

Figure 3. The average success rate of questions for the outcome SŠ C.B.3.2. according to Maude's typology

DISCUSSION AND CONCLUSION

Even though a more complete evaluation of the new curriculum will require a longer outcome adoption tracking time, as well as a larger sample, the primary results can be a cause for optimism. The results of observing two different generations across two

different school years on only one educational outcome are, at the very least, satisfactory. The focus of this research is an analysis of knowledge retention for the outcome GEO SŠ C.B.3.2. through multiple different levels of analysis. This contributes the, so far, poorly explored topic in educational geography. Research showed a very high level of geographical knowledge retention (44,95%) at the Osijek-Baranja County area for students enrolled into the first grade of high school in the school year 2019/2020. This generation of students was taught according to the new geography curriculum since first grade of high school. Results show that students, after an initial exam in the school year when the knowledge for the selected outcome was fresh and new, solved the initial exam only 3,86% poorer than the first one (48,81%). By comparing these results with the previous 4th grader generation, we noticed that the results are somewhat poorer (50,48%), which can be ascribed to the different written examination structure i.e., the task types and formulations, as well as cognitive levels for which the outcome content tested. Whether this is an exception or a rule, the future results of the currently ongoing longitudinal research will show. The level of retained knowledge may be compared with the results and trends determined in the paper by Vranković et al. [16].
The fact that students, in all examinations, achieved the overall best results in the questions examining the cognitive levels of understanding and application is satisfactory, as well as being in line with the demands of the new curriculum. The results gained by this research significantly differ from the results in the paper by Vranković et al. [19], according to which the tasks with the highest success rate are those on the cognitive level of remembering, and those with the lowest success rate are those on the cognitive level of application. There is clearly room for progress in the teaching of the outcome content at the lowest cognitive level of remembering because the students achieved the worst results in those questions (33,95%). A suggestion for advancing the achievements of students in those outcome contents would be the application of conceptual schemes, the effect of which could then be explored by new research. Latin et al [8] speak on the possible beneficial consequences of such a decision. By observing retention across cognitive levels of Bloom's taxonomy, we notice the anomaly that students achieved better results on examinations done half a year after learning and teaching for the levels of remembering and application than it was in the examinations done immediately after learning and teaching, at the end of the school year. The reason might be student motivation near the end of the school year, which is when the first examination was done. The longitudinal research will potentially also demonstrate whether this is a coincidence not only for the GEO SŠ C.B.3.2. outcome. We notice a high level of knowledge retention for the questions at the cognitive level of understanding (54,46% as opposed to 63,60%).
Individual question analysis according to task type demonstrated expected results. The closed-type tasks, in which a student can use, apart from knowledge, various methods and strategies which need not always be a demonstration of outcome adoption, were done with the highest success rate. On the other hand, the extended-answer type tasks in which there is no possibility to guess the correct answer, were done with the lowest success rate. Such results in the success rate of closed-type tasks and extended-answer type tasks have been determined in other research of the level of geographical knowledge at the end of geographical education [19]. Knowledge retention was somewhat harder to determine using this analysis due to the various types of tasks included in the written examinations in May 2022 and November 2022. The comparison could only be done for the short-answer type tasks which were done with an average success rate of 45,54% in September, while the same task type was done with an average success rate of 33,18% in November,

which could be considered a satisfactory level of knowledge retention. The success rate of short-answer type tasks in this exam significantly differs than the success rate determined by other papers [19, 22].

In the spirit of actualization and development of educational geography in Croatia, this paper also dealt with the current debate on powerful geographical knowledge by observing individual questions through the lens of the five types of Maude's typology of powerful geographical knowledge. In the exams done in May and November 2022, three out of five typology types were determined (type 1, type 2 and type 4). Observed as a whole, the questions representing type 4 powerful geographical knowledge were done with the highest success rate (49,41%). However, the differences are not substantial. The type 1 questions were solved somewhat worse (47,86%) followed by type 2 questions in last place with an average success rate of questions being 44,80%. On the other hand, the best knowledge retention was determined for type 1 questions (60,35%) and type 4 questions (59,05%), meaning that students adopted best the knowledge enabling them to think about the world in a different and new way. As such, they are prepared to be active members of their communities in all current debates on various levels of activity (local, national, global). The non-existence of type 3 and 5 questions is noticeable. Considering the fact that these examinations attempted to determine the adoption of individual outcomes, the tasks did not ask students to self-reflect on their own knowledge, which would belong to type 3 questions. On the other hand, the themes of this outcome are a novelty in the teaching of geography in Croatia. However, they are not a novelty to the immediate environment of the students because, as members of their communities, they can experience the consequences of urban heat islands, or notice the characteristics of smart, inclusive and sustainable cities which have their own elements (traffic system, waste management, energy system, land usage). Therefore, we cannot say that the knowledge tested in these examinations expand student knowledge on parts of the world previously unknown to them. We can compare the estimation of content adoption of the new outcomes in geography classes in Croatia only with the results of the state competition held for third grade students in 2022 immediately after the process of learning and teaching. 16 students took part in the state competition, among which there were no students from the Osijek-Baranja County. One task checked for the understanding of the urban heat island. Students were successful in solving the task in 78,1%. The second task, which checked the identification of influence of industrial objects on day and night air temperatures, was done with more success (87,5%), whereas the task which checked the influence of lakes on the edge of the urban area was done with a 68,75% success rate.

As one of the few papers dealing with determining knowledge retention in Croatia, this paper contributes the further development of a young discipline in geography – educational geography. As such, it can serve as a template on the basis and methodology of which similar research could be done on other outcomes or on all outcomes of one of the four basic concepts (spatial identity, spatial organizations and processes, sustainability).

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SECTION

SOCIO-ECONOMIC GEOGRAPHY

RURAL TOURISM OF WESTERN SERBIA - CHARACTERISTICS AND TRENDS

DOI: https://doi.org/10.18509/GBP23327k
UDC: 338.48-6:379.845]:303.62(497.11-15)"2020"

Kristina Košić
Mirjana Penić
Aleksandra Dragin
Igor Stamenković
Maja Mijatov
University of Novi Sad, Faculty of Sciences, Trg Dositeja Obradovića 3, Novi Sad, **Serbia**

ABSTRACT

Rural tourism is an important form of tourism industry which plays important role and gives many benefits to rural areas community. Increased interest of domestic tourists in rural destinations during 2020. has shown that in the conditions of a pandemic, priorities in tourism development are changing. Western Serbia is a tourist region with the longest tradition and the strongest competitive position in rural tourism in Serbia. In order to provide a clearer insight into the characteristics and trends of rural tourism of Western Serbia, a survey was conducted. Answering short and concise questions, 100 respodents (tourists) assessed the current state of the tourist offer of observed region and suggested activities that can improve the quality of the tourist experience. Respondents singled out the most attractive localities, motives for visits, satisfaction with service, quality of accomodation, the presence of traditional food and drinks, as well as the authenticity of souvenirs. They also assessed satisfaction with the elements of tourist infrastructure, as well as all other entities whos contribute to the development of rural tourism.

Keywords: rural tourism, Western Serbia, characteristics, trends, survey

INTRODUCTION

The development of rural tourism is closely connected with the preserved life environment, cultural values and prosperity of local residents, which otherwise presents a great opportunity for the development of tourism in Serbia. Nowadays, the number of tourists seeking a return to nature and its original values is increasing. There is an increase in demand for green destinations and protected natural regions, for clean and free recreation areas, for active holidays and self-expression, there is an increase in demand for healthy food and environment. Realization of all these things enables tourists to discover the quality of life and their own cultural roots. The development of rural tourism is affected by multiple factors, including flora and fauna as primary ones, as a natural foundation on which a tourist offer is based. Only when the natural environment, landscape units and specific beauties of a region attract tourists, there are grounds for working on other aspects of motivating tourists.

Rural areas have extremely different characters ranging from suburban village territories, to pastures on high mountains. Rural areas are very rich and varied as far as landscape diversity and present cultural heritage are concerned, and they are a huge reserve of skills and energy of people [7], [3].

These are the very reasons why the tourist region of Western Serbia, as being extremely rich in all the necessary resources, deserves more attention when it comes to the development of rural tourism [13].
Its current level is far below the one which can be reached by sustainable and long-term planned activities in the field. Although the very beginnings of this type of tourist movements have a long tradition, it is necessary to constantly direct them towards a more productive way of development.

CHARACTERISTICS OF THE OBSERVED AREA

The region of West Serbia in broader sense, includes a part of Serbia bordering with rivers Sava in the North, Drina in the West and with the valley of rivers Kolubara,Ljig, Dicina and Ibarin the East. This part of Serbia is rich in natural beauties. A bigger part of West Serbia belongs to geographical region of Podrinja which includes Macva and Zlatibor's District. [6].
This paper takes into consideration the touristic region of West Serbia in the narrow sense, where besides municipalities belonging to Zlatibor's District, Ivanjica is included as well, even though it officially belongs to Morava's administrative District. [12] According to available information in touristic region West Serbia, according to the number of registered people 348,841 lived there in 2002. and in 2011. 316,976 people lived there, representing a decrease of 9.13%. The density of population was 32.5 people living per a square kilometer [12].
In the period between 2005. and 2010. there was a noticeable change in the arrival of tourists in the touristic region of West Serbia. When the arrivals of domestic tourists are mentioned 203,624 arrivals were recorded, which represents a decrease compared to the years of 2007. and 2008. when a record number 223,500 of arrivals was recorded. The decrease of almost 10% can be explained with the effects of the economic crisis during 2008, but also with the separation of Montenegro in 2006.making them foreign tourists and causing less tourists coming from this country. On the other hand, in the same period there was a noticeable trend of growth of number of arrivals of foreign tourists which in 2010. was 34,749 which was a growth of almost 135% compared to 2005. In 2011. according to the available information from the Republic Institute for Statistics, a conclusion can be made that the dominant destination was Zlatibor, from municipality Cajetina, which achieved an increase of 11% in tourist arrivals and 18% in overnight stays compared to the arrivals and overnight stays in 2010. [14] In 2019. Zlatibor is still the most visited destination in Western Serbia, with an increase in the total number of tourists by 65% compared to 2011 [16].

REVIEW OF THE LITERATURE

The complexity of tourism and tourist needs of world population influence the change of tourist request. Requests for new and specific forms of tourism are characteristics of the development of this activity in the beginning of the 21st century. New forms of tourism are more and more requested in the tourist market. It gives a chance for rural areas to be included equally with their tourist offer if they have certain potentials and adequate personnel that could include those potentials on tourist market. [1], [17] There is no commonly accepted definition of rural tourism since different countries have different criteria for defining rural area. Rural tourism has a plethora of definitions, from the very minimalist one: "any tourism activity that takes place in rural areas" [2] to more elaborate ones such as the definition by [9] who defined rural tourism as a discrete activity with distinct characteristics which may vary in intensity, and by area. According to [20] "the content of rural tourism covers tourism in orchards, farm, culture, life, scenic areas, religious activities, food and air in rural areas." It comprises rural production, living and ecology, including production: agricultural-activity oriented tourism (agro-tourism or leisure agriculture); living: culture-based activities (cultural and historical tourism, or museum tourism), and ecological: nature-oriented recreation activities (nature tourism, agro-tourism, green tourism or eco-tourism).

The term "rural tourism" has been accepted by European Union, and as such it refers to all tourist activities in rural areas. Special forms of rural tourism could be: tourism on homestead, hunting, fishing, ecotourism, health, recreational, residence (houses for vacation), educational, adventurous, transit, camping tourism, continental nautical tourism, gastronomically and ethno gastronomically, tourism of protected parts of nature, cultural tourism, religious, other special forms [8].

The development of rural tourism is well reflected in the academic literature through many disciplines, including: geography, sociology, economics, and environmental studies [21] Tourism has long been considered as a potential means for socio-economic development and regeneration of rural areas, in particular those affected by the decline of traditional agrarian activities [5] Numerous studies deal with the different benefits derived from rural tourism that can be used as potential solutions to many of the problems facing rural areas [22] ,[10], [19] ,[4] These benefits are: economic growth, socio-cultural development, environmental function.

In addition to the positive effects of rural tourism, negative effects that may accrue include: cost increase of public services such as waste disposal, resulting from increased demand, the creation of partial/temporary jobs, increases in land prices and even a situation in which local residents are unable to acquire more dwellings in the area, and over dependency of the community on one industry, the success of which is not under the local community's control [21], [18], [11].

Serbia has a great potential regarding the offer of rural tourism because of the preserved nature, traditional and autochthonous values. Rural tourism in Serbia presents a significant factor of multifunctional rural development, which is confirmed by numerous theoretical and empirical researches.

METHODOLOGY

Scientific methods are chosen based on the defined problem of research, set goals and tasks. The methods largely used while writing this paper are the following: the so-called desk-research method, the method of research on the field, the comparative method, the questionnaire method or poll method, the method of analysis and synthesis. Applying the stated scientific methods, the corresponding conclusions have been reached and constructive propositions for modifying the existing and creating new directions of successful tourism development within a protected area have been made. The strategy of tourism development in Serbia recognizes the southwestern Serbia cluster, which the observed region belongs to, as one of four key clusters of tourism development. This cluster is a favourite destination of primarily domestic tourists, but also of tourists from the region, as well as a smaller number of tourists from the European market.

The strategy within the southwestern Serbia cluster includes a wider circle of municipalities, compared with the region included in this research (the municipalities included in the research are Arilje, Ivanjica, Kosjeric, Pozega, Priboj, Prijepolje, Sjenica, Bajina Basta, Uzice, Nova Varos, Cajetina).

RESULTS AND DUSCUSSION

With the goal of providing a clearer insight into characteristics and prospects which currently follow the development of rural tourism of the observed region, a survey has been conducted. Namely, on a sample of 100 subjects, one can get a clear picture of the state, as well as establish any potential activities which can improve certain parameters.

By answering short and concise questions, the subjects, except in introductory eliminating questions, had an opportunity to assess, based on their own experiences, the current state of the tourist offer of the region. They named the most visited localities, motives of the visits, satisfaction with the service, and here we primarily think of the kindness of local residents, the quality of accommodation, presence of traditional food and beverages, as well as the authenticity of souvenirs. They also assessed their satisfaction with elements of tourism infrastructure, as well as all other subjects contributing to the development of rural tourism with their role.

The questions included in the questionnaire can be divided into three groups based on the form: dichotomous questions, questions with scalar answer and questions with multiple answers, and according to the content, they can be divided into questions about the structure of the subjects, questions about visiting rural areas and questions about the quality of received serviced.

The poll was conducted in the period between December 2018 and March 2019, in most cases by filling in the electronic form, which understood sending the questionnaire via email or via modern social networks.

The structure of subjects. The first question is about the sex of subjects, and is answered by all subjects, and the results show that there are 72 female and 28 male subjects.

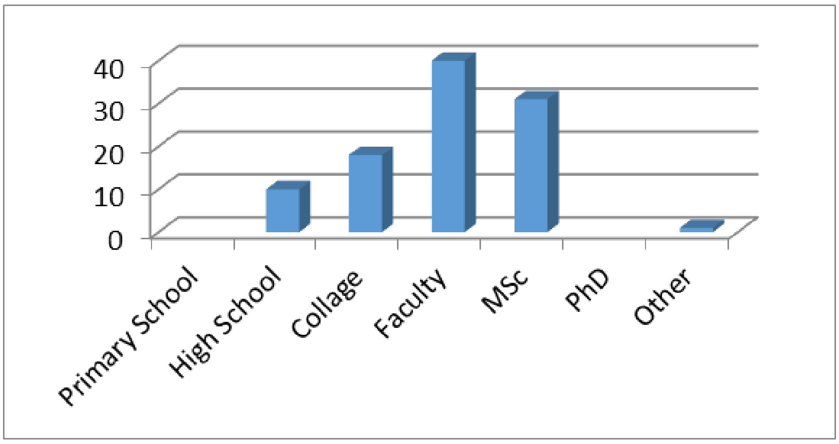
Despite the wish that the ratio is as even as possible, due to the lack of interest of male subjects in filling in the poll, the ratio in percentage is 72:28 in favour of the female subjects.

In the second question, the subjects circle, from the given options, their occupation, and the options are the following: pupil, student, employed, retired, and unemployed. The results show that 45 subjects are students, who make the largest group when compared with others. Following students in number are the employed (35), who are followed by the unemployed (19) and a pupil.

The nonexistence of a larger number of subjects who are employed can be considered a potential weakness because it is this group of the market segment that makes the largest number of tourists, i.e. people with purchasing power. It is logical to assume that students, the unemployed, and pupils will be a minority when we speak of tourist movements. What also poses a problem is the fact that pensioners in our country cannot afford longer and more frequent journeys, as is the case in the developed countries, such as Germany.

The third question refers to the age of subjects. The offered answers are: 20 or less, 21-40, 41-60, and over 60. Of course, a slightly younger group of subjects prevails, considering the number of students, thus, there are 90 subjects between 21 and 40.

The level of education of subjects is of great importance for understanding the essence and significance of the problem, as well as for getting variable results. Besides primary and high school, the subjects can choose college, faculty, master's degree, PhD, as well as naming other higher titles. Graph 1 shows the percentage of subjects. Subjects with faculties are the most numerous (40), they are followed by the young with master's degrees (31), then there is a smaller number of subjects with a college (18), there are only 10 subjects with secondary education, and only one subject with primary education. The heterogeneous picture of the structure of subjects offers us a trustworthy picture, since it is important to see how different segments experience similar phenomena, and how it is reflected in their life experience.



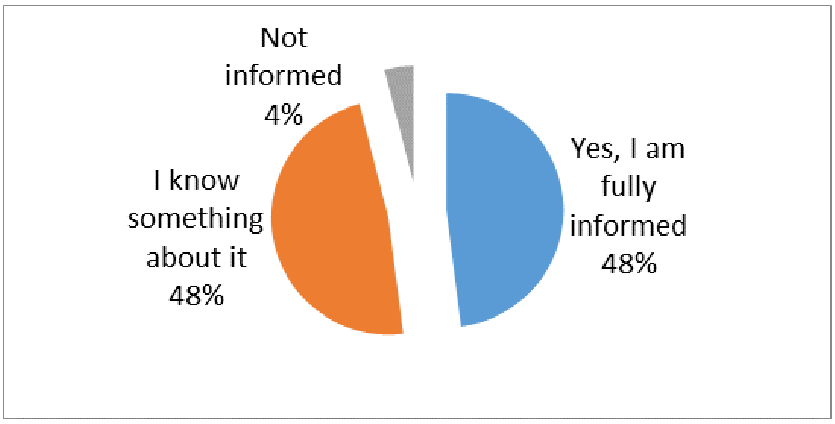
Graph 1. The level of education of respondents.Source: Results of authors' survey.

The height of monthly income points to real possibilities of tourists, when it comes to consumption and at the same time the generation of income from rural tourism. The following options are offered in the questionnaire: persons without income – this group mainly includes students, those with income up to 200 EUR, from 201 to 400 EUR, from 401 to 600 EUR, from 601 to 1000 EUR, and subjects with income over 1000 EUR. The results of the poll show that subjects without income are the most numerous (46), which is a result of the bad economic situation of most people in our country. There are 22 subjects with average income, slightly fewer people have income below average (15), up to 200 EUR, there are 13 subjects with income between 401 and 600 EUR whereas only 4 subjects have a somewhat higher income.

Affinities of subjects concerning the observed region. The second part of the poll contains questions which indicate the concrete experiences of subjects with the observed region. In the question which refers to the first associations of the subjects, when we speak about rural tourism in the region, there are various answers.

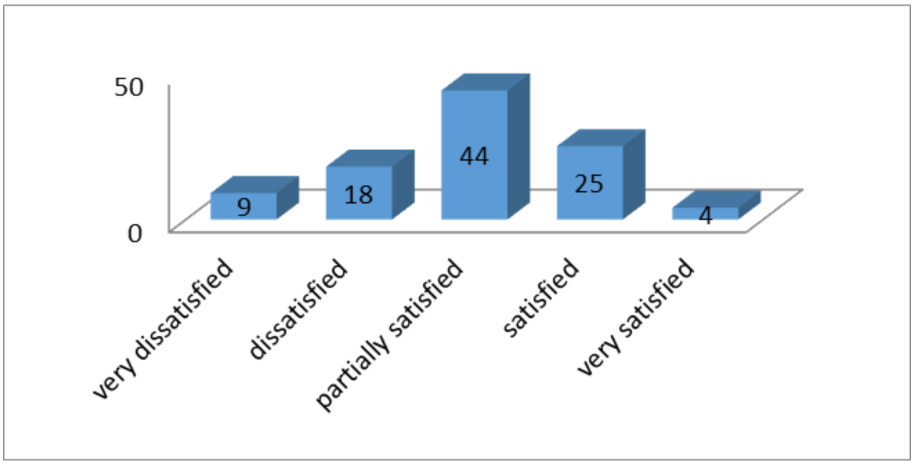
The first association for the visitors is, in most cases, Zlatibor with its natural beauties, lakes and surrounding villages such as Sirogojno and Mokra Gora. Villages near Kosjeric are also attractive, for example Mionica. Then there are other mountains such as Tara, Zlatar and Golija. Alongside with the natural wealth of the region, the subjects have accentuated the cultural and historical heritage, traditional food and beverages, as well as interesting and authentic old customs.

All the mentioned indicate the presence of positive tendencies in the development of rural tourism of the region. However, some subjects point out to some of the negative associations, such as unemployed experts or insufficiently used capacities during the whole year. The question whether and to what extent they are informed of this kind of tourist movement is answered by equal numbers of subjects who confirm that they are completely informed (48) and those who know something about it, while the number of those who are not informed at all is small (4) (graph 2).



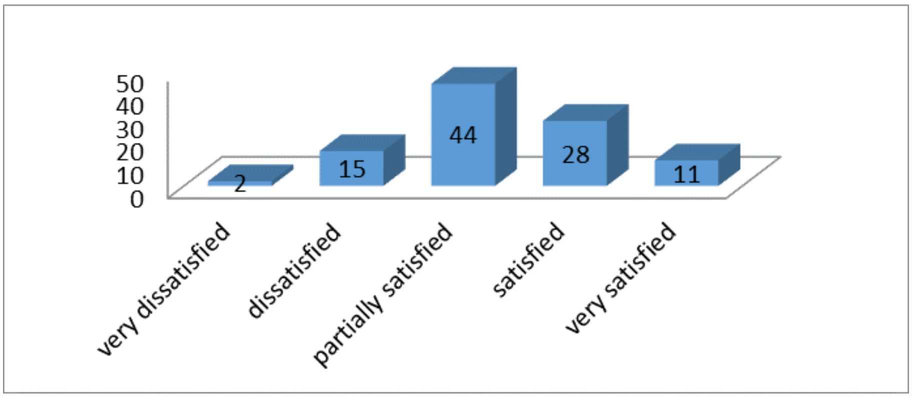
Graph 2. The level of awareness of the respondents about the characteristics of rural tourism. Source: Results of authors' survey

Most subjects share the opinion that this region has good conditions for the development of rural tourism (87), while the rest of the subjects (13) partly agree with this statement.
According to the subjects' opinion, the greatest potentials of Western Serbia, regarding the development of rural tourism, are preserved and beautiful nature (37), traditional food and beverages (27), villages (houses and objects) (14), people and customs (8), homecraft (4), manifestations and performances (3), cultural and historical sights (3) and other (all potentials together) (4).
Considering the growing trend of rural tourism in the world, as well as in our country, it is logical that the interest in staying in one of these regions is increased. There is a large number of subjects (76) who would gladly spend their holiday or school break in the countryside. The number of those who might decide to spend a holiday in the countryside is smaller (21), while there is an insignificant number of subjects who are unwilling to venture upon this type of holiday (3).
Those who have already spent time in one of these rural areas have visited: Zlatibor, Tara, Kokin Brod, Bajina Basta, Mokra Gora (Drvengrad), Kosjeric and the surrounding villages, Jasenovo village, then Arilje, Ivanjica and the surrounding villages, Cajetina, Prijepolje, ethno village Kostunici, Sirogojno, etc.
The durations of their stays were different. 24 Subjects spent four to seven days, 22 stayed for a day without staying over night, 18 subjects spent more than seven days, 17 subjects spent two days, and 14 subjects spent three days there.
Motives of tourists to visit these areas are different. Most of them come because of the necessary rest and relaxation (35), and a lot of them (25) because of the preserved nature as well. Visiting family and friends is a motive for 15 subjects and a great deal of subjects (8) name more than one motive as a reason for the visit. Visitors are also motivated by cultural contents (4), traditional manifestations (3), interesting customs (2), then participation in agricultural works and old crafts, traditional food and beverages, socializing with hosts and health content.
The adequate knowledge that tourists have before arriving at a destination, as well as after the arrival, and during the stay is crucial. It is important that information is well structured and easily accessible. The extent to what this segment satisfies the needs of tourists in both cases can be seen in graphs 3 and 4.



Graph 3. Availability of information before arriving at the destination.
Source: Results of authors' survey.

The biggest number of the questioned tourists got their information on destinations of West Serbia through the Internet (65%) and from friends and relatives (24%), and the smallest number of the questioned ones (11%) got the information via other media (TV, radio, newspapers, fairs).

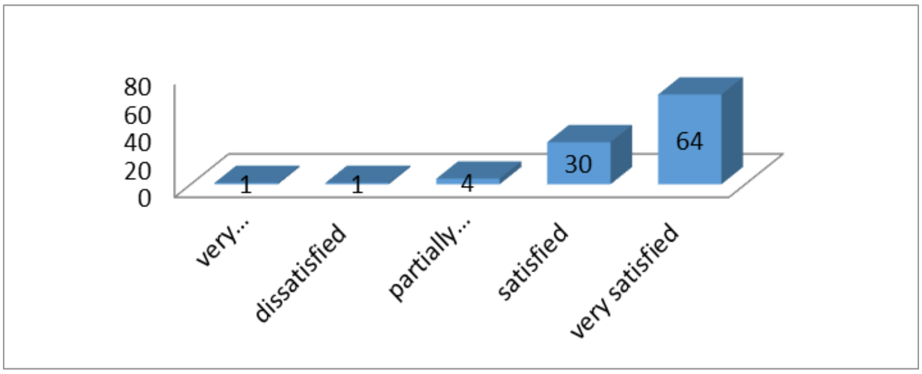


Graph 4. Availability of information to the destination itself.
Source: Results of authors' survey.

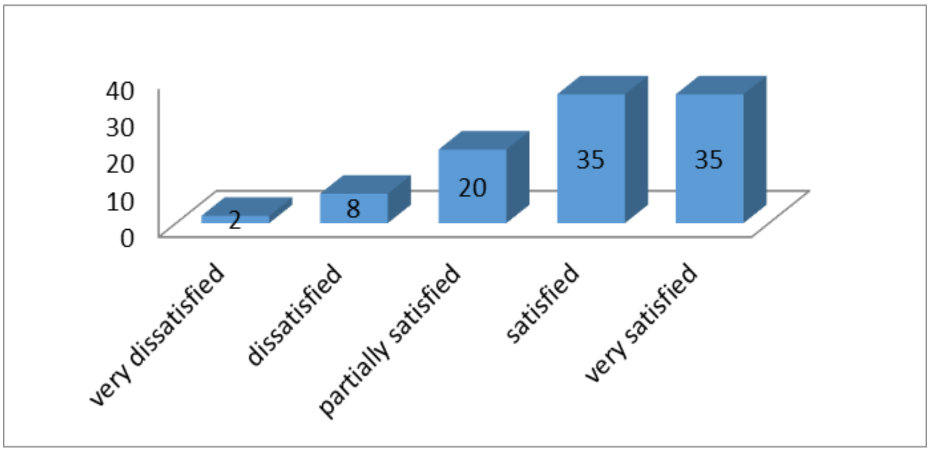
The situation is much similar in both shown cases, i.e. tourists are mostly partly satisfied, satisfied or very satisfied, while the percentage of those who are dissatisfied is smaller, but this fact should by no means be neglected. Even the percentage of the dissatisfied can be overcome by numerous promotional activities.

The development of rural tourism of a region cannot be imagined without traditional food and beverages. Since this region is characterized by varied offer in the field, the results of the research are in accordance with it. Visitors are very satisfied with what the region has to offer when it comes to traditional food and beverages (graph 5).

Besides traditional food and beverages, the authentic image of a rural area is completed with a rich offer of souvenirs with traditional motives. The making of souvenirs should involve and employ a large part of local residents, which brings multiple benefits. As far as souvenirs are concerned, the opinion of the subjects is divided (graph 6).

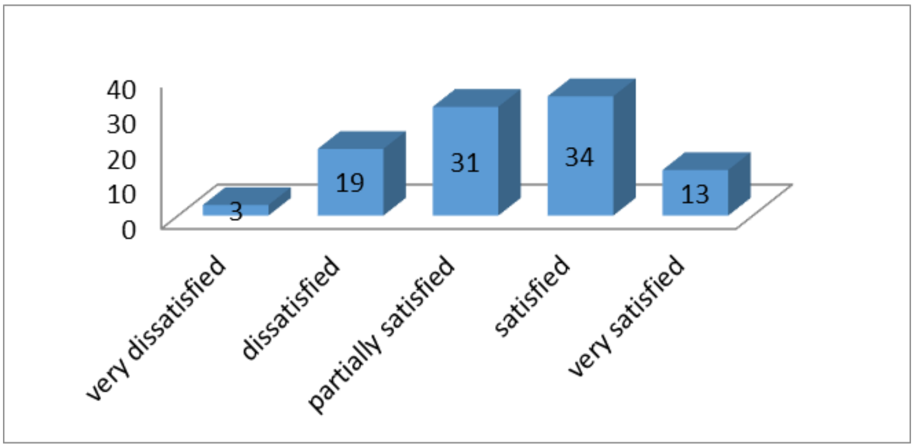


Graph 5. Satisfaction gastronomic delights of the region. Source: Results of authors' survey

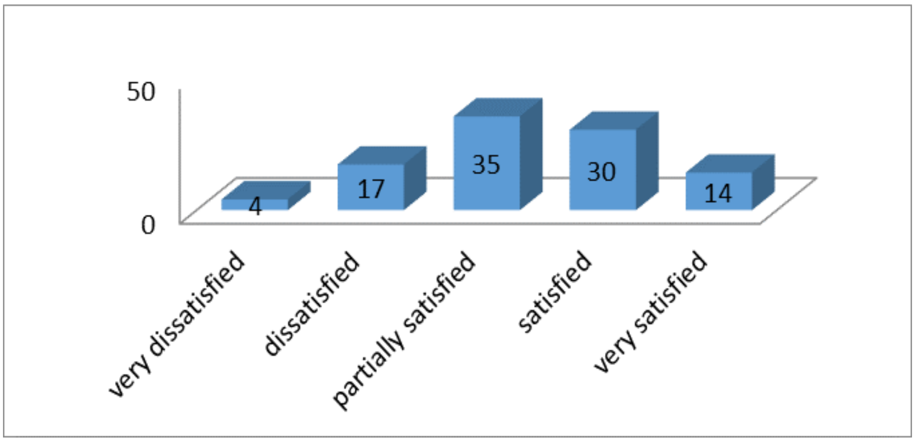


Graph 6. Satisfaction with offer of souvenirs. Source: Results of authors' survey

Harmonization of accommodation and hospitality facilities with the surrounding area is significant for the development of rural tourism. It is desirable that these facilities do not impair the look of the environment with their exterior. The subjects are mainly satisfied (graph 7 and 8), but that there is a significant number of those who are not completely satisfied. It is assumed that these are tourists who stayed on Zlatibor or its surroundings, where there degradation of the surrounding area has occurred due to uncontrolled construction.

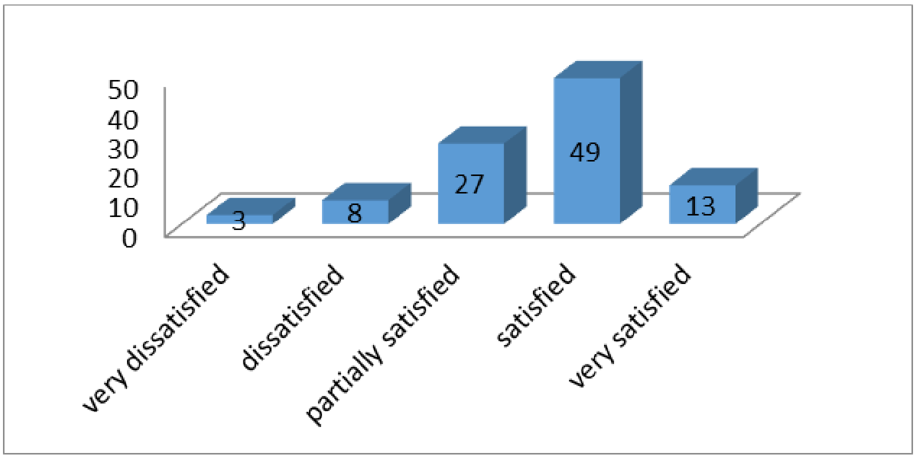


Graph 7. The the degree of distortion of the environment with inappropriate exterior of facilities for accommodation. Source: Results of authors' survey.



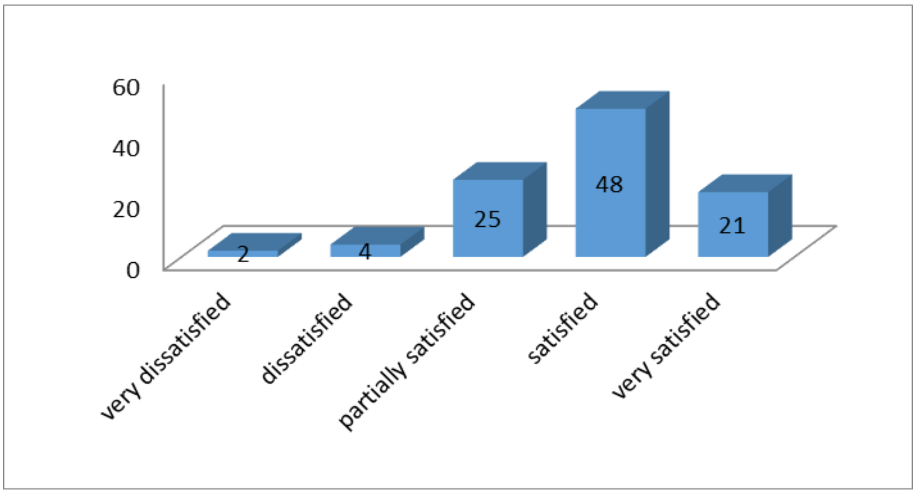
Graph 8. . The degree of distortion of the environment with inappropriate exterior of catering facilities. Source: Results of authors' survey.

The quality and price of service ratio is closely connected with all the previously mentioned parameters (Graph 9). It is of great importance that this ratio is satisfying, i.e. that tourists receive a certain service for their money, and not be deprived in this respect. This is also important because it is the only way that will bring a tourist back to the destination, or that a tourist will communicate lovely experiences to their acquaintances. It is generally known that "mouth-to mouth" type of promotion is perhaps the most successful way of making a region more popular.



Graph 9. Satisfaction with the quality and price of services rendered. Source: Results of authors' survey.

The overall mark of the offer of the tourist region of Western Serbia is shown in graph 10. Only a few subjects are either very dissatisfied (2) or dissatisfied (4), 25 subjects are partly satisfied, 48 are satisfied and 21 subjects are very satisfied with the offer of the region. The small number of dissatisfied is the result of all weaknesses which are defined through the analysis of other questions. By finding ideal solutions, all weaknesses can absolutely be overcome.



Graph 10. The total score of the region offers. Source: Results of authors' survey.

CONCLUSION

Rural tourism is becoming a more and more popular form of tourist movement and it is a fact that the tourist region of Western Serbia has all potentials of taking its high, competitive position in the market. The problems which are currently present can be overcome in a very reasonable period of time, only if one acts adequately and in accordance with the principles of sustained development. In this research paper there can be seen all potentials which refer to the wealth in natural potentials, cultural and historical sights, the state of infrastructure, material basis and other elements contained in the offer. Alongside with the potentials, there are weaknesses. In order to affirm rural tourism in accordance with its potentials and to make the region an even more important tourist destination of Serbia, it is necessary to implement a series of planned activities. It is necessary to categorize accommodation facilities, increase the number of households that engage in this business, especially in the southeastern part of the region, and educate the local population about new trends in tourism. Tourist posts should be opened in villages and they should, in cooperation with local authorities, work on the promotion of tourist values of rural areas of the region. Since modern tourism cannot be imagined without quality infrastructure systems, one of the main conditions refers to the construction of quality roads and additional contents which will make the stay in a village more complete (sport fields, swimming pools, trim tracks, mountain paths, souvenir shops et al.). It is necessary to professionally design a tourist offer and contents of the stay, together with emphasizing the functions of villages in the region, relying on natural potentials, activities and lifestyle of local residents – from agricultural activities (in a recreational form for tourists), through preparing national dishes, handcrafting, to participating in folklore manifestations, festivals of folk creativity and celebrations. The development of rural tourism is not possible without activities related to its promotion in tourism market. The production of promotional material, internet presentations, constant presence in the media, social networks and at trade fairs are necessary activities in the creation of conditions for a sustainable development of rural tourism. Stays of tourists in villages of the region should be based on an optimal combination of attractive natural and anthropogenic values. This is why the development of tourism must be approached seriously and professionally, fully respecting the principles of ecological protection.In the present material and organizational conditions, rural tourism in the region is almost completely turned to domestic market, especially to tourists from larger towns. Foreign tourists are rare and they mostly come from ex-Yugoslav republics. If the stated activities are realized, conditions will be made for the promotion of tourist offers of villages of the region in markets of developed European countries, which have an emphasized interest in and need for this kind of tourism.

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